Engineering Library

JUN 20 1930

The Engineer.

Established 1856. Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 28, ESSEX ST., STRAND, LONDON, W.C. 2.

VOL. CXLIX.—No. 3882] LONDON: FRIDAY EVENING, JUNE 6, 1930 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

HEATING.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Tuesday, 24th June, 1930, for LOW-PRESSURE HOT WATER HEATING at the Post Office, &c., Falmouth.

Drawings, specification, a copy of the conditions and form of contract, bills of quantities and forms for Tender may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles-street, London, S.W. 1, on payment of One Guinea. (Cheques payable to the Commissioners, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. 5154

HOT WATER SERVICE.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Thursday, 26th June, 1930, for the SUPPLY and INSTALLATION of a HOT WATER SERVICE at Queen Anne's Chambers, Westminster, S.W.

Drawings, specification, a copy of the conditions and form of contract, bills of quantities and forms for Tender, may be obtained from the Contracts Branch, H.M. Office of Works, King Charles-street, London, S.W. 1, on payment of One Guinea. (Cheques payable to the Commissioners, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. 5166

Board of Education.

APPOINTMENT OF ASSISTANTS AT THE SCIENCE MUSEUM.

The Board of Education invite APPLICATIONS for TWO APPOINTMENTS as ASSISTANT on the HIGHER TECHNICAL STAFF of the SCIENCE MUSEUM, one in the Industrial Engineering and Manufactures Department and one in the Mechanical Engineering, Land Transport and Construction Department.

Applicants must have attained the age of 22, and as a rule must not have exceeded the age of 30 on the 1st April last, but in exceptional cases applications from persons above the age of 30 on that date will be considered. Candidates who have served in H.M. Forces or as established Civil Servants may be allowed a deduction from actual age.

Candidates for the post in the Industrial Engineering Division will be expected to have had a sound general training equivalent to that required for a University Honours Degree in Electrical Engineering. For the post in the Mechanical Engineering Division similar qualifications in Mechanical Engineering will be required. In both cases candidates should have some practical experience. A knowledge of one or more modern languages is desirable.

The beginning salary for Man Assistants entering at the age of 25 or over is £250 per annum plus current cost-of-living bonus. The beginning salary for an Assistant entering below the age of 25 will be £200, rising to £250 on attaining 25. Assistants are eligible for promotion to posts with a maximum salary of £900 per annum plus bonus.

The beginning salary for Woman Assistants entering at the age of 25 or over is £230 per annum plus bonus. Woman Assistants entering below the age of 25 will receive an initial salary of £190, rising to £230 on attaining the age of 25.

The current Civil Service cost-of-living bonus is added to salary. At present the bonus on £190 is £95; on £200, £99; on £230, £106; and on £250, £111.

A fee of £8 will be payable by successful candidates before certification.

Further particulars and application forms may be obtained from the DIRECTOR and SECRETARY, Science Museum, South Kensington, London, S.W. 7, and the application form, when filled in, should reach the Director not later than the 4th of July, 1930. 5139

Crown Agents for the COLONIES.

COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POSTS:—

M/2255.—ASSISTANT ENGINEER REQUIRED by the GOVERNMENT of HONG KONG for three years' service and possible permanency. Salary £460, rising to £500 a year by annual increments of £20 and thereafter, in the event of the appointment being made permanent, by further annual increments of £20 to £700 a year, and then by annual increments of £25 to £1000 a year. Payable locally in dollars under a compensation scheme at present in force at a favourable rate of exchange. Free passages. Candidates, unmarried, age 24 to 30, must have passed Sections A and B of the examinations to qualify for the A.M.I.C.E. Diploma, or hold professional qualifications recognised by the Institution of Civil Engineers as exempting from these examinations. Must be good draughtsmen, well up in levelling land and marine surveying and sounding and must have had some experience in design and construction of port works generally.

M/2274. — ENGINEER REQUIRED by the GOVERNMENT of NIGERIA for the Maintenance of the Lagos Waterworks for two tours of 12 to 18 months' service and possible extension. Salary £720, rising to £920 a year by annual increments of £40. Free quarters and passages. Liberal leave on full salary. Candidates, 28 to 40 years of age, must be Corporate Members of the Institution of Civil Engineers and the Institution of Water Engineers. Must have had good experience in the management of waterworks, including triple-expansion pumping machinery, chemical treatment and filtration processes, also in modern waste detection methods and in the application of bye-laws and collection of revenue.

M/2269.—WATER and SANITARY ENGINEER REQUIRED by the GOVERNMENT of TRINIDAD for the Public Works Department for three years' service. Salary £750, rising to £800 a year by annual increments of £25. Free passages. Candidates, 35-40 years of age, must be A.M.I.C.E. Must have had considerable experience in the preparation of schemes pertaining to water and sanitary works and the execution of such works.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting the reference number against the appointment for which application is made. 5169

SITUATIONS OPEN

AN OLD-ESTABLISHED STEEL WORKS REQUIRE GENTLEMAN as DEPARTMENTAL MANAGER, with commercial and technical training, and up to date in Aircraft and Motor Car Steels.

Applications, stating experience, training and terms, to be addressed to 5163, The Engineer Office. 5163 A

THE ENGINEER.

PLEASE MAKE A RECORD THAT ALL FUTURE COMMUNICATIONS SHOULD BE ADDRESSED TO:—

28, ESSEX STREET, STRAND, LONDON, W.C. 2.

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

A Searchlight for Air Defence. (P. 638)
(D. BENGTSON.) THE ENGINEER, 6 - 6 - 30.

The Automatic Stabilisation of Ships No. X. (P. 625)
THE ENGINEER, 6 - 6 - 30.

"Electricals": Summer Meeting. (P. 638)
THE ENGINEER, 6 - 6 - 30.

Horizontal Opposed-Piston Geared Marine Oil Engines. (P. 622)
(T. PETTY.) THE ENGINEER, 6 - 6 - 30.

The Kitson-Still Locomotive. (P. 631)
THE ENGINEER, 6 - 6 - 30.

The Faraday Centenary Celebrations. (P. 637)
THE ENGINEER, 6 - 6 - 30.

The Wilbur Wright Lecture. (P. 628)
(H. R. RICARDO.) THE ENGINEER, 6 - 6 - 30.

Municipal Electrical Association—No. II. (P. 639)
THE ENGINEER, 6 - 6 - 30.

Technological Civilisation. (P. 636)
THE ENGINEER, 6 - 6 - 30.

INDEX TO ADVERTISEMENTS, PAGE 79.

PUBLIC NOTICES

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.

Principal:
B. MOUAT JONES, D.S.O., M.A. (Oxon).

UNIVERSITY OF MANCHESTER
(FACULTY OF TECHNOLOGY).
DEGREE COURSES IN TECHNOLOGY.

The Prospectus gives particulars of the courses leading to the Manchester University Degrees (B.Sc. Tech., M.Sc. Tech., and Ph.D.) and Certificates in the Faculty of Technology, in the following Departments:—

MECHANICAL ENGINEERING
(Prof. Dempster Smith, M.B.E., M.Sc. Tech., M.I.M.E.).
ELECTRICAL ENGINEERING
(Prof. Miles Walker, M.A., D.Sc., M.I.E.E.).
MUNICIPAL ENGINEERING
(G. S. Coleman, D.Sc. Eng., A.M. Inst. C.E., A.M. Inst. M. and Cy. E., F.R. San. I.).
APPLIED CHEMISTRY, including General Chemical Technology, Metallurgy and Assaying, Fermentation Processes (including Brewing), Electro-Chemistry, Photography, Colouring Matters, Foodstuffs and Fuels
(Prof. James Kenner, D.Sc., Ph.D., F.R.S.).
TEXTILE CHEMISTRY (Bleaching, Dyeing, Printing and Finishing), Paper Manufacture
(F. Scholefield, M.Sc., F.I.C.).
TEXTILE TECHNOLOGY
(Prof. W. E. Morton, M.Sc. Tech.).
INDUSTRIAL ADMINISTRATION (Post-Graduate Certificate Course)
(J. A. Bowie, M.A., D.Litt.).

Prospectus will be forwarded free on application to the REGISTRAR, College of Technology, Manchester. 5151

The University of Sheffield.

ASSISTANT LECTURESHIP IN MATHEMATICS FOR TECHNICAL STUDENTS.

The Council are about to APPOINT an ASSISTANT LECTURER in MATHEMATICS for Technical Students. Salary £300 per annum.

Applications should reach the undersigned, from whom further particulars may be obtained, by June 20th, 1930.

W. M. GIBBONS,
Registrar.
5105

PUBLIC NOTICES

Bengal-Nagpur Railway Company, LIMITED.

The Directors are prepared to receive TENDERS for:—
550 STEEL WAGON AXLES.
906 LAMINATED LOCOMOTIVE SPRINGS.

Specifications and forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad-street, London, E.C. 2, on or after Wednesday, 4th June, 1930.

A fee of 10s. will be charged for each copy of the specification, which is NOT returnable.

Tenders must be submitted not later than Noon on Friday, 20th June, 1930.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board,
R. GRANT,
5157 Secretary.

County Borough of Doncaster.

PUBLIC ASSISTANCE DEPARTMENT.
THE POOR LAW INSTITUTION, DONCASTER.

TENDERS are INVITED from responsible and experienced Contractors for the SUPPLY, ERECTION and SETTING to WORK of a CENTRAL HEATING APPARATUS, including Central Calorifier Plant, Mains, Radiators and Domestic Hot Water Heaters, together with Live Steam Services. Also the PROVISION of TRENCHES for MAINS, with incidental Builder's Work.

Specifications may be obtained and drawings seen at the office of the Consulting Engineers, G. J. Gibbs and Partner, 7, Lune-street, Preston, on deposit of the sum of £5, which will be refunded on receipt of a bona fide Tender and return of all documents.

Tenders, endorsed "Tender for Central Heating," to be delivered to the undersigned not later than 10 a.m. on Thursday, June 26th, 1930. The Council do not bind themselves to accept the lowest or any Tender.

Dated this 23rd day of May, 1930.
W. BAGSHAW,
Town Clerk.
Public Assistance Offices,
Wood-street, Doncaster. 5102

PUBLIC NOTICES

City of Salford.

HEATING AND HOT WATER SYSTEMS AND KITCHEN APPARATUS—HOPE HOSPITAL.

TENDERS are INVITED in accordance with plans and specifications prepared by the Corporation's Consulting Engineer, George W. Martin, M.I. Mech. E., M. Cons. E., 33, Arran-road, Catford, London, S.E. 6, which may be seen either at the Public Health Department, 143, Regent-road, Salford, or at the Consulting Engineer's Office.

Application for copies of the plans and specifications must be made not later than Tuesday, the 17th June, 1930, and must be accompanied by a fee of Two Guineas, which will be returnable on receipt of a bona fide Tender which is not subsequently withdrawn.

Tenders, endorsed "Heating, &c.—Hope Hospital," must be in my hands not later than Twelve Noon on Monday, the 30th June, 1930.

H. H. TOMSON,
5155 Town Clerk.

City of Salford.

ELECTRIC LIGHTING INSTALLATION FOR NEW NURSES' HOME—HOPE HOSPITAL.

TENDERS are INVITED in accordance with plans and specifications prepared by the Corporation's Consulting Engineer, George W. Martin, M.I. Mech. E., M. Cons. E., 33, Arran-road, Catford, London, S.E. 6, which may be seen either at the Public Health Department, 143, Regent-road, Salford, or at the Consulting Engineer's Office. Application for copies of the plans and specifications must be made not later than Tuesday, the 17th June, 1930, and must be accompanied by a fee of Two Guineas, which will be returnable on receipt of a bona fide Tender which is not subsequently withdrawn.

Tenders, endorsed "Electric Lighting—Hope Hospital," must be in my hands not later than Twelve Noon on Monday, the 30th June, 1930.

H. H. TOMSON,
5156 Town Clerk.

Coventry Corporation.

BROWNSHILL GREEN WATER SCHEME.
CONTRACT No. 4.
PUMPING MACHINERY.

The Corporation invite TENDERS for the complete INSTALLATION of a High-class PUMPING PLANT in DUPLICATE.

Each set will comprise a Vertical Electric Motor driving a combined High-lift Vertical Centrifugal Bore-hole and Force Pump to raise 30,000 gallons per hour against a head of 341ft., including friction, together with all ACCESSORIES, etc., to make the Plant complete in every detail.

There will also be ONE or TWO BOOSTER SETS for 15,000 gallons per hour working on a nett head of 90ft.

The work will also include subsidiary plant, including Depth Recorder, Venturi Meters, Heating Apparatus and General Equipment.

Copies of the conditions, specification, schedule of prices and form of Tender, may be obtained from the Engineer, Dr. Herbert Lapworth, M. Inst. C.E., 25, Victoria-street, Westminster, on or after May 26th, 1930. The application must be accompanied by a cheque of £3 payable to the Coventry Corporation, which will be refunded on return of the documents, or after the receipt of a bona fide Tender and the documents required.

Facilities for examining the drawings, for inspecting the Site and general information can be obtained on application to the Manager, Water Department, the Council House, Coventry.

Tenders are to be sent on the form supplied, and with the annexed documents must be enclosed in a sealed cover endorsed "Brownshill Green Water Scheme: Tender for Contract No. 4," addressed to and reaching the undersigned not later than 10 a.m. on Wednesday, June 18th, 1930.

Only Tenders for Vertical Electric Motors and Centrifugal Borehole Pumps from experienced manufacturers will be considered.

The Corporation do not bind themselves to accept the lowest or any Tender.

FREDERICK SMITH,
Town Clerk.
The Council House, Coventry,
May, 1930. 5089

TO CONTRACTORS.

The Commissioners of Northern LIGHTHOUSES invite TENDERS for COVERING the BOTTOM of a BERTH in Granton Harbour, which is used by their steamers, with a LAYER of BLUE CLAY over an area of 933 superficial yards to a depth of at least 2ft. For full particulars apply to Mr. D. A. Stevenson, Engineer to the Commissioners of Northern Lighthouses, 84, George-street, Edinburgh.

Offers, in sealed envelopes, marked on outside of envelope "Tender for Clay in Berth," to be lodged with the undersigned not later than Noon on Monday, 16th June.

The Commissioners do not bind themselves to accept the lowest or any Tender.

J. GLENCORSE WAKELIN,
Secretary.
84, George-street, Edinburgh. 5142

PUBLIC NOTICES (continued) Page 2.
SITUATIONS OPEN, Page 2.
SITUATIONS WANTED, Page 2.
AUCTIONS, Page 80.
PARTNERSHIPS, Page 2.
MISCELLANEOUS, Page 2.
EDUCATIONAL, Page 2.
BUSINESSES and PREMISES (For Sale, etc.). Page 80.
MACHINERY, &c., WANTED, Page 80.
PATENTS, Page 4.
FOR SALE, Pages 2, 4 and 80.
AGENCIES, Page 2.
WORK WANTED, Page 80.
FOR HIRE, Page 80.

For Advertisement Rates see Leader Page.

PUBLIC NOTICES

Metropolitan Water Board.

TENDERS FOR THE MANUFACTURE, DELIVERY AND ERECTION OF ONE STEAM-DRIVEN CENTRIFUGAL PUMPING ENGINE (Capacity 18 M.G. per 24 Hours, Head 25ft.), AT KEMPTON PARK PUMPING STATION.

The Metropolitan Water Board invite TENDERS for the MANUFACTURE, DELIVERY, and ERECTION of ONE STEAM-DRIVEN CENTRIFUGAL PUMPING ENGINE at their Kempton Park Pumping Station, Hanworth-road, Sunbury Common, Middlesex.

Forms of Tender, conditions of contract, specification and drawings may be inspected without payment of a fee at the Offices of the Board, Chief Engineer's Department (Room 173), on and after Monday, 2nd June, 1930.

Contractors desirous of tendering may obtain the necessary documents from the Chief Engineer on production of an official receipt for the sum of One Guinea, which must be deposited with the Accountant to the Board and which will be returned on receipt of a bona fide Tender accompanied by all the above-named documents and drawings. Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Centrifugal Pump, Kempton Park," must be delivered at the Offices of the Board (Room 122) not later than 11 a.m. on Monday, 30th June, 1930.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
26th May, 1930. 5109

Metropolitan Water Board.

TENDERS FOR THE SUPPLY OF STORES, &c.

The Metropolitan Water Board invite TENDERS for the SUPPLY of the undermentioned STORES and SERVICES, &c., for the period of twelve months, commencing 1st August, 1930 :—

Tender No.
2. Brushes, Brooms and Handles.
5. Cotton Waste, Engine Wipers, Cleaning Cloths, &c.
6. Hemp, Yarn, Rope, House Flannel, &c.
10. Lead, Zinc and Glass.
13. Oilman's Sundries, Soaps, Tar, Gas Mantles, Metal Polish, &c.
14. Packings, Rubber Goods, Hose and Leather Belting, &c.
15. Paints, Varnishes, Linseed Oil, Turpentine, &c.
18. Scrap Iron—Purchase and Removal of.
24. Electric Lamps.

Tenders must be submitted on the official forms, which may be obtained from the Chief Engineer, by personal application at the Offices of the Board (Room 155) or upon forwarding a stamped addressed sack envelope.

Applicants should refer to the number of the Tender for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board," and endorsed in the manner indicated in the form of Tender, must be delivered at the Offices of the Board (Room 122) not later than 11 a.m. on Friday, 20th June, 1930.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
26th May, 1930. 5108

Metropolitan Water Board.

DISPOSAL OF SURPLUS PLANT.

The Metropolitan Water Board invite TENDERS for the PURCHASE and REMOVAL of SURPLUS PLANT, comprising Two Vertical Compound Engines and Centrifugal Pumps, by Gwynnes, approx. H.P. 20, steam pressure 40 lb., pumps 12in. delivery, together with Condensers, Air Pumps, Fittings, &c., at their works at Hanworth-road, Sunbury-on-Thames.

ALTERNATIVE OFFERS are INVITED for the whole of the PLANT as SCRAP METAL.

The plant may be inspected at the above-mentioned works between the hours of 10 a.m. and 4 p.m. (12 noon, Saturday) on application to the Resident Foreman at the Kempton Park Works, Hanworth-road, Sunbury.

Forms of Tender, containing particulars of the plant and conditions of sale, may be obtained from the Chief Engineer by personal application at the Offices of the Board (Room 155) or upon forwarding a stamped addressed sack envelope.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Surplus Plant," must be delivered to the Offices of the Board (Room 122) not later than 11 a.m. on Tuesday, 17th June, 1930.

The Board do not bind themselves to accept the highest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
31st May, 1930. 5141

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, ASSISTANT ENGINEER, to be Correspondent on Machinery matters, Salesman for Diesel Engines and other Machinery. Engineer who understands working principles of Diesel Engines and who can supervise the erection of same. Knowledge of Spanish desirable. For the Far East. State salary required.—Write, Z.F. 77, care Deacon's, 9, Fenchurch-avenue, E.C. 3. 5140 A

A PROGRESSIVE FIRM of MACHINERY MERCHANTS is considering the APPOINTING of several whole-time DISTRICT REPRESENTATIVES.

Only applications from up-to-date men having actual experience in selling Power Plant, Machine Tools, Contractors' Plant, &c., will be considered, and those having a connection in any of the following areas will receive preference :

The West Country, East Anglia, Lancashire and Cheshire, Derbyshire, Notts. and Lincs., London and Home Counties.

Address, 5152, The Engineer Office. 5152 A

AN OLD-ESTABLISHED STEEL WORKS have VACANCIES for TWO REPRESENTATIVES, with commercial and technical training, and knowledge of Aircraft, Motor Car and Special Steels generally.

Applications, stating experience, training and terms to be addressed to 5162, The Engineer Office. 5162 A

CONSTRUCTIONAL ENGINEER, London, REQUIRED, to Organise and Take Charge of the Erection of a Large Plant in connection with the Gas Industry. Commencing August. Applicants should give full particulars of experience, qualifications, age, salary required, &c.—Address, P7107, The Engineer Office. P7107 A

ENGINEER, SENIOR, with Knowledge of Overseas markets, REQUIRED by Specialist Manufacturers in London area developing export market in Domestic and Heavy Electrical Engineering Products. Experience, age, and salary.—Address, 5055, The Engineer Office. 5055 A

HIGH-CLASS ENGINEERING SALESMAN of proved ability REQUIRED, to take over exclusive sales territory industrial North. Experience in use of Heat Economy Instruments and associated Plant desirable. Preference shown to applicants with good practical boiler experience.—Address, stating age, earnings desired, date free, and full particulars, 5148, The Engineer Office. 5148 A

LEASE OF IMPOSING OFFICES FOR SALE.
33, NORFOLK STREET, STRAND, W.C. 2.

In consequence of the recent amalgamation of "THE ENGINEER" LTD., proprietors of "The Engineer," with MORGAN BROS. (PUBLISHERS) LTD., proprietors of "The Ironmonger" and "The Chemist & Druggist," the offices of the three journals will shortly be transferred to new and more commodious freehold premises which have been acquired at 28-31, Essex Street, Strand, W.C. 2.

The remainder of the lease, covering a further twenty-five years, of the present offices of "The Engineer" at 33, Norfolk Street, Strand, W.C. 2, is in consequence for sale. This particularly well lighted five-storey building has an area of 8,200 sq. ft., and occupies a site at the corner of Norfolk and Howard Streets, adjacent to the Temple Station, whence Westminster and the City may be reached in a few minutes. The building is of modern construction and has a fine and distinctive elevation. It is in good order throughout, and vacant possession can be had in June next. Rent £1,600. Moderate price. For further particulars apply to:—

WHATLEY, HILL & CO.,
24, Ryder Street, St. James', S.W. 1.

LEASE OF IMPORTANT CITY OFFICES FOR SALE.
42, CANNON STREET, E.C. 4.

In consequence of the recent amalgamation of Messrs. MORGAN BROTHERS (PUBLISHERS) LTD., proprietors of "THE IRONMONGER" and "THE CHEMIST AND DRUGGIST," with THE ENGINEER, LTD., proprietors of "THE ENGINEER," the offices of the three journals have been moved to new and more commodious freehold premises which have been acquired at 28-31, Essex-street, Strand, W.C. 2.
The lease of the entire premises, of which the four well-lighted upper floors have been in occupation of Morgan Brothers (Publishers) Ltd., the Ground Floor and Basement being sub-let to the Aerated Bread Co., Ltd., is in consequence for sale.
Alternatively, the four upper floors (which have also an entrance to Garlick Hill), having a total area of about 7,000 sq. ft. would be let.
The premises are in good order and vacant possession can be had in June next. Rent £2,000 per annum, inclusive of rates.

For further particulars apply to :

Messrs. FAREBROTHER, ELLIS & CO.,
29, Fleet Street, E.C. 4.

SITUATIONS OPEN (continued)

WANTED, DRAUGHTSMAN, Experienced in Asphalt and Tarmacadam Plants, Concrete Mixers, and Screening Plants, for East of England district. Applicants to state age, experience, and salary required.—Address, 5172, The Engineer Office. 5172 A

WANTED, Experienced TRANSFORMER DRAUGHTSMEN.—Address, stating age, full particulars of experience, and salary required, 5145, The Engineer Office. 5145 A

CHEMICAL DRAUGHTSMAN WANTED by Bristol firm; must have had experience in Plant Layout and Design, and possess initiative.—Address, stating experience and salary required, 5160, The Engineer Office. 5160 A

DRAUGHTSMAN (MECHANICAL) WANTED AT ONCE by Engineering Firm in Southall (Mddx.); must have had full shop experience, reliable on Calculations and Designing; quick worker essential. With application state fully training, experience, references and salary required.—Box 2, Smith's Bookshop, Southall. P7113 A

DRAUGHTSMAN REQUIRED, Experienced in design of Elevators and Conveyors.—Write, stating age and salary required, to "C. D.," c/o J. W. Vickers and Co., Ltd., 24, Austin Friars, E.C. 2. 5153 A

DRAUGHTSMAN REQUIRED, Used to Designing and estimating Weights of Railway Tyres, Wheels and Axles. Preference given to man having previous experience of this particular class of work.—Address, P7109, The Engineer Office. P7109 A

DRAUGHTSMAN WANTED, First-class Man, with experience of Water-tube Boiler Layouts and Details.—Address, stating particulars of experience, age, and salary expected, 5149, The Engineer Office. 5149 A

DRAUGHTSMAN, with Thorough Practical Experience in Heat Transfer Plants, Estimating and Design. Pump experience desirable, but not essential. State age, experience, and salary required.—Address, 5158, The Engineer Office. 5158 A

REQUIRED, 2 Good MECHANICAL DRAUGHTSMEN in S.W. London. Permanent positions to suitable men. State age, experience, and salary.—Address, P7112, The Engineer Office. P7112 A

YOUNG MAN REQUIRED for Designing Department of Engineering Firm making all classes of Electrically Driven Cranes; one with University Degree preferred. Age, training, and salary required.—Address, 5170, The Engineer Office. 5170 A

SITUATIONS WANTED

A.M.I. MECH. E., Shortly Disengaged, DESIRES POSITION as Manager of Factory; 8 years' experience of practical management, works, office and stores. Specialities: production and costs. Expert organiser.—Address, P7038, The Engineer Office. P7038 B

FIRST-CLASS MAN (40) SEEKS COMMERCIAL APPOINTMENT. Assistant to director or manager or other responsible position. Knowledge costing, estimating, buying, accounts, office control and general commercial matters; 17 years last post with engineering firm. Thoroughly reliable and capable. Excellent credentials.—Address, P7105, The Engineer Office. P7105 B

SITUATIONS WANTED (continued)

ABLE ENGINEER, with Wide Continental experience of factory installation and operation, including engines, boilers, electricity, water softening, refrigerating and building construction, SEEKS POSITION as CHIEF ENGINEER to English Factory or Factories.

Address, P7110, The Engineer Office. P7110 B

AN ENGINEER, Possibly Not Suitable to the requirements of every firm, but the very man for some, enthusiastic, adaptable, reliable and trustworthy, with Technical College training and practical experience in works, offices and on sales, REQUIRES RESPONSIBLE POST where his unusually wide and general experience will be of service.

A genuine prospective employer can have my services gratis for one month. Will you give me the chance to prove my worth ?

Address, P7104, The Engineer Office. P7104 B

BORER, Pearn-Richards Machines, Age 32, with 14 years' experience of high-class work, gear boxes, jigs, &c.; splendid reference.—R. SHEARER, 3, Hopton-street, Worcester. P7103 B

MECHANICAL ENGINEER (25) DESIRES APPOINTMENT; public school, 3 years' apprenticeship, foundry, pattern, machine, fitting shops and D.O.; 1st class honours degree; 8 months' subsequent works and commercial experience; excellent refs.—Address, P7116, The Engineer Office. P7116 B

MR. H. E. PARRATT, M.I. Mech. E., DESIRES REPRESENT First-class FIRM British Engineers in Paris. Speaks fluent French. Wide range engineering experience.—Address, 9, Rue Perignon, Paris, 15me, France. P7009 B

PRACTICAL COMMERCIAL ENGINEER DESIRES POST, Manager or Responsible Position. Wide experience management, general engineering and foundry. Excellent references.—Address, P7031, The Engineer Office. P7031 B

REORGANISATION of FACTORIES, Including production methods, costing and stores systems, and office, UNDERTAKEN by Expert Organiser, A.M.I. Mech. E. First-class testimonials. All-round experience, home and abroad.—Address, P7039, The Engineer Office. P7039 B

SALES MANAGER, with First-class Connection amongst leading petrol and oil companies, Government Departments, and large number of industrial firms in London area, REQUIRES SIMILAR POST.—Address, P7074, The Engineer Office. P7074 B

TO MANAGING DIRECTORS. — MECHANICAL PRACTICAL ENGINEER (40) DESIRES CHANGE, works manager, production engineer, chief inspector. All-round experience mass and quality production. Good organiser. References O.K.—Address, 5175, The Engineer Office. 5175 B

Replies to Box No. Advertisements should in future be addressed to "THE ENGINEER," 28, Essex St., Strand, London, W.C. 2.

PARTNERSHIPS

A. M.I.C.E., M.I.M.E., &c., with Extensive continental experience, SEEKS £1500 PARTNER, having similar qualifications, to START AGENCY or CONSULTING BUSINESS in London.—Address, P7111, The Engineer Office. P7111 C

EDUCATIONAL

Correspondence Courses
OF PREPARATION FOR THE
Examinations of the
INST. OF CIVIL ENGINEERS,
INST. OF MECH. ENGRS.,
INST. OF STRUCTURAL ENGRS.,
UNIVERSITY OF LONDON, &c.,
are personally conducted by
Mr. Trevor W. Phillips,
B.Sc., Honours, Engineering, London University, Assoc. M. Inst. C.E., A.M.I. Struct. E., M.R.S.I., F.R.S.A., Chartered Civil Engineer, &c.
For full particulars and advice apply to :—36, DALE-STREET, LIVERPOOL (Tel., Bank 1118). LONDON OFFICE : 65, CHANCERY-LANE, W.C. 2. EX.

1929 EXAMINATION RESULTS.

The T.I.G.B. maintains its Splendid Exam-Success Record.

At all the 1929 Professional Examinations—A.M.Inst.C.E., A.M.I.Mech.E., A.M.I.E.E., etc.—the candidates who were trained by The T.I.G.B., obtained a Pass Percentage of over 90%.

The T.I.G.B.'s policy of furnishing the highest possible standard of Tutorial Service has brought about a large increase in enrolments both from bona fide exam-candidates and from other keen students. T.I.G.B. TRAINING IS BEING CHOSEN BECAUSE IT IS OBVIOUSLY PRODUCTIVE OF SATISFACTION AND SUCCESS. Therefore, whatever your aim may be —a Recognised Professional Qualification—or the Special Technical Knowledge needed in a responsible post—you can select the appropriate T.I.G.B. course with complete confidence.

WRITE TO-DAY for FREE copy of "The Engineer's Guide to Success," 124 pages, containing the widest selection of home-study engineering courses in the world, and mention the branch, post or qualification that interests you, to

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN (*Established* 1917).
76, Temple Bar House, London, E.C. 4.

AGENCIES

EXPERIENCED ENGINEER, A.M.I.C.E., M.I.M.E., DESIRES LONDON AGENCY for good provincial manufacturing firm.
Address, P6991, The Engineer Office. P6991 D

INSPECTING ENGINEER, Experienced, Glasgow district, UNDERTAKES SUPERVISION WORK and TESTING for Contractors or Consulting Engineers.—Address, P7051, The Engineer Office. P7051 D

LONDON REPRESENTATIVE,
M. Inst. C.E. & M.I.E.E.,
with COMMERCIAL and SALES EXPERIENCE, desires to get in touch with a sound ENGINEERING FIRM requiring man of social standing to REPRESENT THEM in LONDON.

An appointment could be arranged through P7114, The Engineer Office.
P7114 D

WELL-KNOWN FIRM of GEAR SPECIALISTS and ENGINEERS INVITE REPLIES with full particulars and terms for AGENCIES in—
(1) Glasgow and Scotland.
(2) S. Wales.
(3) Newcastle and N.E. Coast.
Address, 5146, The Engineer Office. 5146 D

MISCELLANEOUS

ENGINEERS

CAN'T WE GET TOGETHER?

All we ask is the chance to prove that you can earn £300, £400, £500 per year and more. Other men are doing it, and you can do the same. We have an unrivalled and world-wide organisation waiting to help you, whether you be novice or expert. If you wish for something more than a "bread-and-butter" job you owe it to yourself to investigate our Service. Our handbook,

"ENGINEERING OPPORTUNITIES"

has pointed the way to better things to over 20,000 of your fellows. It contains details of A.M.I. Mech. E., A.M.I.C.E., A.M.I.E.E., A.M.I.A.E., A.M.I. Struct.E., C. & G., G.P.O., &c., Exams., and outlines Home-Study Courses in all branches of Electrical, Mechanical, Motor and Wireless Engineering. In a brilliant article Professor A. M. LOW shows clearly the chances you are missing. The Book and our Advice are quite free.

We guarantee "NO PASS—NO FEE." Don't miss this opportunity. Send a postcard NOW (state Branch, Post or Exam.).

BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY.
22, SHAKESPEARE HOUSE, 29, OXFORD STREET, LONDON, W. 1.
5173

FOR SALE

BOILERS, TANKS and AIR RECEIVERS.

New, several, 11ft. long by 5ft., Rec., 80 lb. W.P.
Lancashire Boiler, 30ft. by 7ft., 80 lb. W.P.
Cornish Boiler (1915), 24ft. by 6ft. 6in., 80 lb. W.P.
TANKS (Boiler Shells), 30ft. by 8ft., extra heavy.
Ditto 30ft. by 7ft.

H. & T. DANKS (Netherton), LTD.,
Boilermakers and Engineers, Netherton, DUDLEY.
4722 G

For continuation of For Sale Advertisements see page 4.

A Seven-Day Journal

British Airship Policy.

DURING a debate on Tuesday in the House of Lords on British air services overseas the Minister for Air, Lord Thomson, intimated in fairly definite terms that, subject to the forthcoming long-distance trial flights of the "R 100" and "R 101" it would be the Government's policy to build an airship of 7,500,000 cubic feet capacity. A vessel of that size, he said, would be a commercial proposition. He hoped that if the trial flights were successful and if careful records were kept of the running costs, consumption of fuel, navigation risks, and so forth, the large shipping companies would become interested in airship services. He also announced that the Consultative Committee set up last July, consisting of Sir Alan Anderson, Mr. Quirey, Mr. Nugent, Sir Wm. Brass, Sir Archibald Sinclair, and Mr. Snell, had reported very sympathetically on the establishment of an Atlantic airways scheme. With the co-operation of the Canadian Government, he was fairly confident that an Atlantic service could be built up that would be able to maintain itself without subsidisation. Lord Thomson revealed for, we believe, the first time the cost involved in building the two airships "R 100" and "R 101." The sum spent on the construction of the two vessels was, he said, £894,000. A further sum of £305,000 had been expended on research connected with the airship programme. All told, the programme, which included the provision of two sheds and three mooring towers and the organisation of ground and meteorological services, had involved an expenditure of £2,300,000. He added that improvements still remained to be effected in the design and construction of the two vessels. These improvements, he said, would considerably lighten the load they could carry, but they would be made in the interests of "safety first," just as every stage in the design and construction of the vessels had been carried out with that watchword in full view. On Wednesday the Under-Secretary for Air, Mr. Montague, gave, in the House of Commons, some additional information concerning the proposed new British airship. It appears that a design contract has been entered into under which a technical staff is now employed investigating possible detail improvements in the design of the airship R100 and studying modifications which might be necessary if it were decided to build an airship of her type having a capacity greater than 5,000,000 cubic feet. Payments under the contract are limited to £2,000 per month. The expenditure to date is £7,800.

The Suez Canal.

THE seventy-sixth annual meeting of the Suez Canal Company was held in Paris on Monday last. The report dealt with 1929 and was remarkably favourable, as the business done exceeded all precedents. The tonnage passing through the Canal rose to 33,466,014 tons, which was equivalent to an increase of nearly 5 per cent. upon the record set up in the preceding year. The number of vessels was 6274 and the average size was 7376 tons, but it is interesting to note that transits made by vessels of over 10,000 were a little more numerous than in 1928. We learn from the report that over 34½ million tons of merchandise passed through the Canal, and that the receipts from vessels were 4 per cent. higher than in the preceding twelve months. Despite the fact that the prospects for the present year are shadowed by the poor results up to date, the company is following its usual policy, and as from September 1st next a reduction of 25 centimes will be made in the transit dues on loaded vessels, bringing the charge down to 6·65f. Hitherto ships in ballast have paid 2·50f. below the normal rate, but as from September 1st they will have to pay only half that rate. The expenditure in 1929 amounted to 311,243,234f., roughly 2½ million pounds sterling, and 100,000,000f. were set aside for improvement works. For the present year the sum so allocated is 80,000,000f.

"London House."

ON Monday, June 2nd, we attended a meeting at the Mansion House, presided over by the Lord Mayor of London, held for the purpose of giving publicity to the scheme for the establishment of "London House," a hall of residence for British and Dominion students in London. The lack of such a residential establishment is keenly felt by the increasing number of students—particularly those from the Dominions—who come to London to pursue their studies. It is proposed to erect London House on a site in Bloomsbury. Indeed, the contract for the erection of the building, it was announced on Monday, has actually been signed. It is intended to extend the establishment as funds become available, and ultimately to provide a dining hall and common rooms, residential accommodation and recreation facilities for several hundred students. At Monday's meeting Mr. L. S. Amery dwelt upon the advantages of the scheme from the Empire point of view, and Mr. H. A. L. Fisher spoke of the educational advantages afforded by London institutions to all classes of students. Mr. Stanley Bruce, late Prime Minister of Australia, welcomed the scheme as a step towards inducing young men from the Dominions to pursue their post-graduate studies in Great Britain, rather than in Germany or America. Sir James Parr, representing New Zealand, expressed the hope that the Dominion Governments would help to forward the scheme by financial contributions. Sir William H. Clark referred to the desire of Canadians to know more about Great Britain and to the difficulty experienced in placing Canadian students and pupils in British institutions. Sir Drummond Chaplin, representing South Africa, dwelt upon the advantages to British students arising from association with students from the Dominions. Lord Moynihan of Leeds emphasised the benefit of the proposed hall of residence, particularly to medical students. Contributions amounting to £130,000 have already been secured by the Dominion Students' Hall Trust, but an additional £120,000 is immediately required. Mr. F. C. Goodenough, chairman of Barclays Bank, Lombard-street, E.C. 3, is acting as treasurer of the fund.

Three Interesting Presentations.

ON Friday last the eighteenth Wilbur Wright Lecture was delivered by Mr. Ricardo before the Royal Aeronautical Society, assembled in the Hall of the Royal Society of Arts. Amongst those in the audience was Mr., now Sir, F. H. Royce, to whom the President, the Master of Sempill, presented the silver medal of the Society, in recognition of his conspicuous work in the development of the Rolls-Royce aero-engine, and particularly the engine of the Schneider Trophy machine, the Supermarine S. 6. After the lecture the Council of the Royal Aeronautical Society gave an admirable dinner in the Athenæum Club. At the conclusion of it Colonel Sempill presented to Sir Richard Glazebrook, Chairman of the Aeronautical Research Committee, a silver box, "to commemorate the twenty-first anniversary of the founding of the Advisory Committee for Aeronautics, 30th April, 1909," and to Lieut.-Colonel Moore-Brabazon he handed a silver aneroid, presented by the President and fellow members of Council of the Society to "commemorate the twenty-first anniversary of his flight on May 2nd, 1909—the first flight in a power-driven aeroplane piloted by a British subject in the British Isles."

Birthday Honours.

OUR readers will have observed with pleasure that the names of several eminent engineers and scientists appear in the list of Birthday Honours. Mr. Basil Mott, a past-President of the Institution of Civil Engineers, who has been connected with many of the great civil engineering works in this country and abroad for years past, and Mr. F. H. Royce, whose name is a household word amongst motorists and aeronauts, have been created baronets, whilst Colonel Frederick Palmer, who is famous particularly for civil engineering work done in India, becomes a K.C.M.G. Knighthoods have been conferred upon Mr. Francis William Goodenough, closely associated with gas undertakings and chairman of the Government Committee on Education for Salesmanship, and upon Mr. Herbert Wright, for long and valuable services to the Imperial College of Science and Technology. Mr. Charles Herbert Bressey, Chief Engineer, Roads Department of the Ministry of Transport, becomes a C.B., and Mr. E. W. Smith, Honorary Technical Adviser to the Area Gas Supply Committee, has received a C.B.E., J. A. B. Horsley, Electrical Inspector of Mines, an O.B.E., and J. E. Haworth, General Manager of the Sewage Disposal Department, Sheffield, an M.B.E. We notice also that several well-known scientists, amongst whom are Prof. Arthur Stanley Eddington and Dr. Leonard Hill, have been knighted.

Railway Catastrophe in France.

THE wreck at Montereau of the express from Paris to Ventimiglia on Sunday evening, June 1st, when seven passengers were killed outright and eight others were dangerously injured, is believed by the police authorities to have been deliberately planned. At half-past ten the train was taking a curve at a speed of 46 miles an hour, which was much less than the maximum allowed. The locomotive left the rails, and after ploughing up the track for a short distance turned over, the driver and fireman being thrown out practically uninjured. The coaches swung round. The first van was smashed and the following coach took up a position at right angles to the locomotive. The end of the coach was telescoped by the next vehicle, which turned over almost alongside the locomotive. The wreck was caused by a truck used for carrying rails. It had been placed across the rails with the wheels on the ballast, so that the locomotive wheels sheared it in two, leaving one half on the ballast while the other half was found under the wreckage. The truck had been left at the side of the track after the reconstruction of the curve, and four men at least would have been required to carry it on to the rails. Although the French Prime Minister was expected to travel by the train, it is not believed that the wrecking of it was inspired by political motives, although a good deal has been made of the fact that there is a strong Communist organisation at Montereau and that the men engaged on permanent way work are largely foreigners, mostly from Eastern European countries. This occasion is probably the first time that all-metal coaches have been in a serious accident. One end compartment was completely telescoped, and it was in it that the passengers were killed, and their bodies and some of the injured passengers had to be removed by cutting away the sides with oxy-acetylene jets. In view of the formidable character of the smash there is a probability that had wooden coaches been used the loss of life would have been greater.

Charing Cross Bridge.

IT seems that all the expenditure on the preparation of a scheme for a road bridge across the Thames at Charing Cross has been in vain, and that a new start will have to be made, for such a bridge will, no doubt, ultimately be built. On June 3rd the London County Council decided to drop the Charing Cross Bill, which had been rejected by the Select Committee of the House of Commons. It appears, however, that another effort may be made to secure parliamentary sanction for some similar scheme, for Sir Percy Simmons, the Chairman of the Improvements Committee, pointed out that the only alternative would be to pull down Waterloo Bridge and to build a wider bridge in its place. It was agreed by the Council that a committee should be appointed representing all interests involved, which should submit within nine months an agreed scheme for the construction at Charing Cross of a road bridge and approaches at an estimated net cost not exceeding £12,500,000.

Tariffs and Motor Cars.

IT appears from correspondence in various papers, notably the *Evening World*, that American manufacturers of motor cars are strongly opposed to the clauses in the new Tariff Bill which is now receiving the attention of Congress. They are in great fear that, if the clauses remain in the Act, their industry, far from being benefited by the assumed protection, will, in fact, be seriously injured. It is pointed out that the automobile trade gives employment to nearly four and three-quarter million people, and is therefore the largest manufacturing industry in the United States. The value of its exports of all kinds connected with motor vehicles amounted last year to no less than 126 million pounds, and one firm indicates that it has trading relations with sixty foreign countries. Of these countries thirty have already instituted reprisals and the others have already made arrangements to increase their tariffs against the United States if the Bill goes through in its present form. This firm has informed the *Evening World* that it anticipates a loss of two-thirds of its foreign trade if the Bill is not materially modified. That loss would necessitate the discharge of something like 40 per cent. of the employees. The presidents of the General Motor Corporation and the Marmon Company are as emphatic. The former says that a revision of tariffs upwards is "in no sense predicated upon sound business policies," and the latter asserts that not only will the increased tariffs deprive the motor industry of the major portion of its foreign trade, but "American methods will be used to manufacture products no longer available from American manufacturers, thus shutting for ever the door to our export markets."

A Proposed Arctic Air Route.

FOR a long time many people have been attracted by the idea of establishing a Transatlantic air service following a route from the north of Scotland by way of the Faroe Islands and Iceland to Greenland, and thence across Baffin Land and over Hudson's Bay to Winnipeg or other Canadian centre. This route provides natural emergency landing grounds over the greater part of its length, and at no point does it involve the crossing of a length of sea exceeding 300 miles. It is announced that on July 3rd a British expedition will leave this country to explore the route. The party, numbering fourteen, is being equipped by certain members of the Royal Geographical Society and a few other benefactors. It will be led by Mr. H. G. Watkins, and will include an air pilot lent by the Air Ministry, a wireless officer lent by the War Office, and, it is hoped, a naval surgeon lent by the Admiralty. The expedition will sail for Greenland in Commander Shackleton's vessel "The Quest," which has been chartered from her Norwegian owners. One of its principal tasks will be to study the meteorological conditions over Greenland, for which purpose it will establish a central base on the south-eastern coast of that territory. For carrying out an experimental flight next year over the whole route, Vickers (Aviation), Ltd., has offered the loan of a "Vellore" freight-carrying machine. This scheme, it would appear, is not the same as that referred to by Lord Thomson in the House of Lords on Tuesday, and mentioned in another paragraph on this page. The Canadian Government is, however, interested in it, as it is in the Atlantic Airways scheme, and it is hoped will undertake the survey work required in the Hudson's Bay and Baffin Land portion of the route.

Possibilities of the Horizontal Opposed-Piston Geared Marine Oil Engine.

By THOMAS PETTY.

THE present position of the internal combustion engine, in its application to marine propulsion, presents a direct, if only partial analogy with a phase in the development of steam turbine driven vessels, and a reversed analogy with the early history of screw propulsion by means of steam reciprocating engines.

The essential simplicity of the direct-connected unit has led to the widespread development of large slow-speed internal combustion engines of various types. The screw propeller, by means of which the transformation of the rotational energy developed in these engines to a form available for propulsion is effected, is not in itself a notably efficient instrument. It requires, for the attainment of its maximum possible efficiency, particularly in the slow and medium-speed vessels to which as yet the oil engine has been principally applied, a speed of revolution so low as to make inordinate demands in regard to the weight, cost and space requirements of the prime mover. Apart from these objections, in the internal combustion engine a progressive increase in mechanical and temperature difficulties is encountered with increase in cylinder sizes, thus promoting a strong tendency to keep the individual cylinder capacity to a minimum for any given duty. In the ultimate compromise, therefore, these engines, although termed slow-speed, rotate at speeds which, in general, are somewhat higher than is compatible with maximum propeller efficiency. The vessels to which they are fitted cannot be expected, in consequence, to exhibit a high overall propulsive coefficient, nor to yield maximum economy of operation on a fuel per ton per knot basis for ships of given dimensions, displacement, lines, and speed.

In the endeavour to cope to some extent with the situation thus created, in the direction both of reducing the weight, cost and space requirements per B.H.P. developed, and of employing a propeller speed more compatible with the requirements for maximum efficiency at a given speed of vessel, there has been a natural progression from the original vertical single-acting form of the marine internal combustion engine to double-acting engines, on both the two and four-stroke cycles, which are also of the vertical type.

These double-acting engines, however, are characterised by very considerable height, and are thus in conflict, in vessels of the liner class with the demand for increasing limitation of the interruptions to upper decks caused by machinery spaces.

The normal employment of forced lubrication, and recent advances with regard to constructive materials of high conductivity and low specific gravity, have minimised some of the most serious objections to high-speed operation which formerly existed. These facts, taken in conjunction with the previous successful development of reliable main power reduction gearing, to meet a partially analogous position in regard to the development of the marine steam turbine, offer an avenue of escape from the difficulties associated with the large slow-speed direct-connected unit, and a number of vessels have been equipped with internal combustion machinery in which the main engines are of the high-speed vertical type connected with the propeller shafts by reduction gearing.

The employment in this way of engines running at high speeds of revolution has rendered possible appreciable reductions in weight and in space occupied, more especially in the vertical direction, and raises the propulsive coefficient by giving complete freedom of choice in regard to propeller revolutions. In some cases the engines have been made non-reversible, and have been connected with the pinions of the reduction gearing through the medium of reversing hydraulic clutches, which at the same time serve to damp out the torque variations of the engines. In other cases the hydraulic clutches have been constructed to function merely as flexible and shock-absorbing couplings, and as a means of ready disconnection, the engines themselves being made reversible in the customary manner. The overall efficiency of the clutches and gearing has been stated as 95 per cent., *i.e.*, 97 per cent. for the clutch and 98 per cent. for the gearing. In spite of these losses, the apparent economy in operation of geared vessels fitted with clutches would appear to indicate a net gain which can only be attributed to the use of a propeller more in consonance with hull characteristics. In the interests of simplicity and a more complete realisation of the potential possibilities of the geared system, however, the elimination of hydraulic clutches is much to be desired.

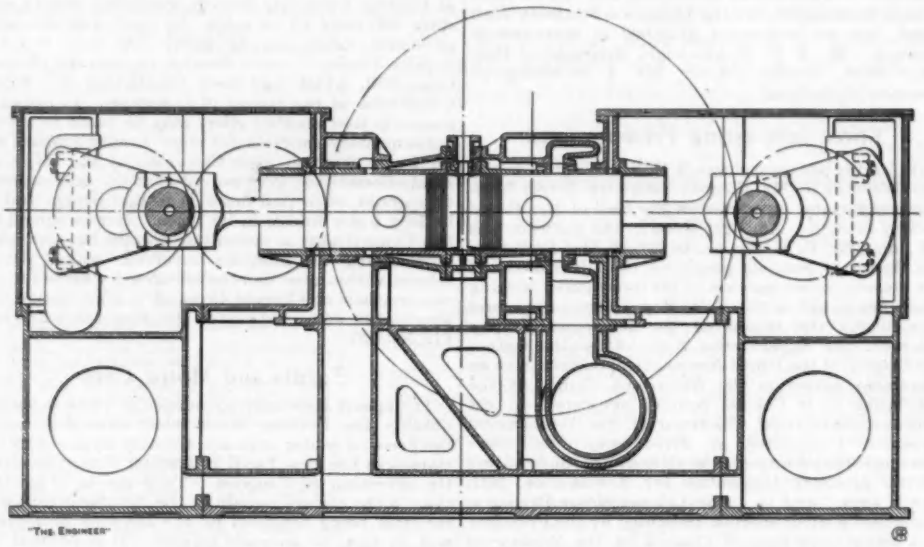


FIG. 1—SECTION THROUGH CYLINDERS OF PROPOSED HORIZONTAL OPPOSED-PISTON ENGINE

The 14,000-ton twin-screw motor liners "Monte Sarmiento," "Monte Olivia," and "Monte Cervantes," built for the Hamburg-South American Company by Blohm and Voss, of Hamburg, present notable examples of the apparently successful application of another type of geared machinery in which the engines, which in this case are themselves necessarily reversible, are rigidly connected to the main pinions without the intervention of hydraulic couplings. Two six-cylinder, single-acting, four-stroke cycle, high-speed, vertical engines are thus geared to each propeller shaft, those of the "Monte Sarmiento" being of the trunk piston type, while in the remaining two vessels the crosshead type of construction has been adopted. The engines being of the four-stroke cycle type, there will only be three power impulses per revolution, and the only damping effect upon the considerable torque variation therefore present is that supplied by fly-wheels of somewhat larger size than usual. A rigidly connected propelling unit of this type, of course, involves careful computation and adjustment of the natural frequencies of the complete system in the design stage if tooth contact is to be preserved in the gears under all conditions of operation. It is claimed that, by the use of geared machinery, the weight of each complete propelling unit, including the thrust block and gearing, has been reduced to 65 per cent. of what would have been required for direct connected four-stroke cycle engines, and 75 per cent. of what would have been required for direct-connected two-stroke cycle engines running at 90 revolutions per minute, the actual propeller speed in the "Monte Sarmiento" being 77 revolutions per minute.

For convenience in reference, the principal particulars of these and other geared oil engine propelling units have been brought together in the first seven columns of Table I., which aims at being fairly representative in regard to type, rather than inclusive in respect to the total number of installations completed or in progress to date.

In each case the engines are of the normal vertical single-piston design of their respective types. It is not the purpose of the present article, however, to deal further with installations of this character, which have rather been cited as indications of the progress so far achieved in the development of the geared main propelling unit, but to describe a proposed application of a special form of the single-acting two-stroke-cycle horizontal engine.

Contemporary with the general development of normal single-piston, vertical, direct-connected marine units of both two and four-stroke cycle, and single and double-acting types, there has been developed in this country, in the Doxford engine, a successful marine motor of the single-acting two-stroke cycle Junker, or opposed piston, type, also in the direct-connected and vertical form. The general advantages of this type of engine are well known, of course, particularly in regard to the absence of cylinder covers and piston-rod glands, the reduction of heat dispersing surface to a minimum, and the capacity of the engine for the efficient combustion of heavy charges of fuel when working at high speeds, due principally to the efficiency of what is, in a general sense, its uni-directional scavenge system, and the exceptionally good form of combustion chamber to which the opposed piston arrangement lends itself.

In the vertical form in which it has hitherto been built, with the opposed pistons arranged above a single shaft, it involves a multiplicity of cranks, and a complexity of the principal articulations,

TABLE I.

Vessel	"Monte Sarmiento"	"Monte Olivia"	"Monte Cervantes"	"St. Louis"	"Vulcan"	"Duisberg"	"Wulsty Castle"	Proposed horizontal opposed piston engines
No. of propellers	2	2	2	2	1	1	1	
No. of engines connected to each propeller	2	2	2	2	2	2	2	
Cycle	Four-stroke	Four-stroke	Four-stroke	Two-stroke	Four-stroke	Four-stroke	Four-stroke	Two-stroke
Single or double-acting	S.A.	S.A.	S.A.	D.A.	S.A.	S.A.	D.A.	S.A.
Description of engines	M.A.N. reversible, trunk piston, supercharged	M.A.N. reversible, crosshead type, supercharged	M.A.N. reversible, crosshead type	M.A.N. reversible	Submarine type, non-reversible	M.A.N. non-reversible, crosshead type	Beardmore-Tosi reversible	Opposed trunk piston reversible
No. of cylinders in each engine	6	6	6	6	6	8	3	6
Bore of cylinders	600 mm.	600 mm.	630 mm.	485 mm.	350 mm.	640 mm.	510 mm.	20in.
Stroke	700 mm.	700 mm.	700 mm.	660 mm.	350 mm.	700 mm.	620 mm.	25in.
Revolutions of engines per minute	215	215	210	225	300	210	240	240
Revolutions of propellers per minute	77	77	75	110	85	79	80	80
Ratio of connecting-rod centres to crank radius	5·0							4·64
Diameter of crank shafts	380 mm.	380 mm.	380 mm.					12in.
Type of scavenge pumps				Turbo				Opposed-piston, reciprocating
Bore of scavenge pumps								48in.
Stroke of scavenge pumps								18in.
	Super-charged. / Without super-charging	Super-charged. / Without super-charging						
B.H.P. each propeller	3500 / 3000	3500 / 3000	3000	6300	620	4010	1600	3500
Brake mean pressure, lb. per square inch	88·7 / 76·0	88·7 / 76·0	70·5	65·3	66·0	68·7	59·8	61·3
B.H.P. per square inch of piston area	0·665 / 0·569	0·665 / 0·569	0·518	0·967	0·346	0·502	0·444	0·9275
Piston speed in feet per minute	988	988	965	975	690	965	980	1000
Single or double helical gearing	D	D		S		S		D
Diameter of pitch circle, main wheels	2292·504 mm.	2292·504 mm.				2588·9 mm.		108·4in.
" " pinions	821·036 mm.	821·036 mm.				1050·0 mm.		36·13in.
Ratio of gearing							2·88 to 1·0	3·0 to 1·0
Type of coupling between engines and gearing	Solid	Solid	Solid	Hydraulic non-reversible	Hydraulic reversible	Hydraulic reversible	Hydraulic non-reversible	Solid

which scarcely find favour in the eyes of conservative designers whose ideal is the maximum of mechanical simplicity. In common with the normal single-piston type of double-acting engine, the vertical opposed piston engine is also of considerable height, although, by an ingenious method of construction, the additional height required for overhauling has been reduced to very moderate dimensions. The fact that in geared oil engine installations it is customary to gear the crank shafts of two engines to each propeller shaft, led the writer to the conclusion that it might be possible, by adopting a horizontal form of construction, to devise an opposed piston geared oil engine in which not only were the advantages of the opposed piston arrangement retained, and its disadvantages

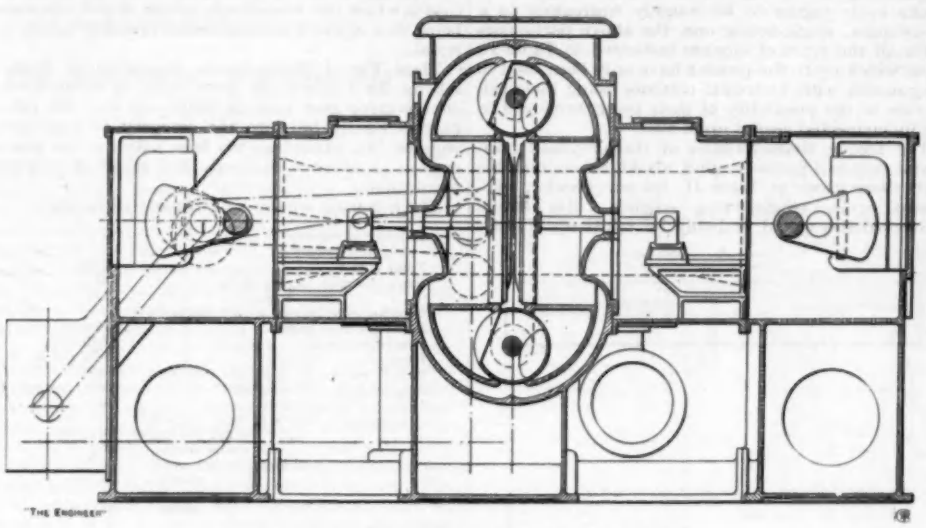


FIG. 2—SECTION THROUGH SCAVENGE PUMPS

eliminated, but in which there might also conceivably be a considerable reduction in height as compared with geared installations employing vertical engines, particularly where these are of the double-acting type.

To test the feasibility of the project, preliminary studies for a tentative design on these lines were embarked upon, some of the results of which are embodied in Figs. 1, 2 and 3, and the appended description, which, however, are necessarily of a provisional character, and cannot be taken as being definitive in matters of detail. For purposes of comparison with existing designs the general particulars of the proposed engine have been included in the final column of Table I.

REDUCTION GEARING.

The selection of a gear ratio which is an exact submultiple of the number of cylinders may provoke adverse comment from gearing specialists, but is merely provisional and a matter which may be satisfactorily adjusted by slight modifications in determining the exact proportions of a final design. To render the operation of the engine possible, the two crank shafts must be arranged to rotate in a clockwise and counter-clockwise direction respectively. This is secured by the interposition of an idler between one of the pinions and the main gear wheel. In Figs. 1 and 3, the idler is shown in the position suitable for a single-screw unit with right-hand propeller, the starboard set of a twin-screw installation with outward turning propellers, or the port set of one with inward turning propellers, the object in each case being to secure an arrangement in which the guide pressure on the combustion stroke is in a downward direction when going ahead. The idler shown in the figures is of the same diameter as the pinions, but, of course, it may be made of any convenient size.

The possibility of varying the diameter of the idler without affecting the gear ratio, in fact, permits of the construction of units of large power without entailing the use of main gear wheels of prohibitive size, and gives a general flexibility to the design. As shown in Fig. 3, the thrust block is incorporated with the forward bearing of the main gear wheel, and the turning wheel secured to an extension of the pinion shaft on the side remote from the idler, arrangements which are capable, however, of obvious modifications.

CRANK SHAFTS.

The crank shafts are made in two parts, each having three cranks of the semi-built type, *i.e.*, the webs are formed in one piece with the crank pins. The stroke-bore ratio, referred to a single piston, is the lowest which will permit of this type of construction. The forward end of the forward half of each shaft is provided with an extension on which is fitted a scavenge pump crank, and in the case of one of them, as shown in the plan view, Fig. 3, the excentrics for the coupling-rod drive to the cam shaft of the fuel pump and manœuvring unit, or, in the case of the adoption of a chain or geared drive, the driving sprocket or gear wheel for that purpose. Rigid claw couplings, of the type familiar in connection with geared turbines, connect the crank shafts to the pinion shafts, the fly-wheels being secured to flanges formed on the engine halves of the couplings. To secure a measure of flexibility the pinion shafts are of hollow form, traversed internally by solid driving shafts of minimum diameter having regard to the maximum torque to be transmitted, and connected at their after ends to the pinion shaft and at their forward ends to the claw couplings above mentioned.

The number of cylinders and cranks that may be employed is not necessarily confined to six, of course, nor is the rigid coupling of the pinions to the crank shafts obligatory, although strongly advocated with a view to simplicity and the avoidance of the extra weight, cost and space requirements of hydraulic couplings.

A compromise in the latter connection might be arrived at in the use of some form of spring coupling.

CYLINDERS AND MAIN FRAMEWORK.

The proposed general design of the main framework is probably sufficiently indicated by the figures without an extended description.

Conformably with general practice, the combustion, compression and inertia loads are taken by through tie bolts, which also serve to secure the main bearing keeps. Strong girders, extending athwartship between the main bearings, which are cast with the box-form crank cases, support the compressive loads induced by the initial screwing up of the tie bolt nuts. An alternative and lighter design would be to form palms upon the tie bolts themselves, secured by studs or bolts to the main bearings. The crank cases at each side are continued down to the tank top, and at the tank top level other cross girders are arranged between them on the centre line of each cylinder. Erections, cast or bolted to these cross girders, form intermediate supports for the cylinders, the support on the scavenge side being cast hollow so as to function as a scavenge air passage. The cross girders are also of hollow form, with fore and aft cross connections between themselves and to the scavenge pump delivery chamber to form a scavenge air main. The spaces below the crank cases are rendered common with the scavenge air delivery system, so as to provide additional air passages and give ample air vessel effect for the equalisation of the supply of scavenge air to the individual cylinders. Each cylinder liner, with its jacket and exhaust and scavenge air inlet chambers, forms a self-contained unit, bolted at its outer ends to the crank cases, and supported at intermediate points from the lower cross girders, there being thus ample provision for the direct transmission of the guide reactions to the tank top. Slip joints are arranged to prevent the imposition of axial loads on the cylinder units, and enable each unit to be removed bodily for overhaul after unshipping the connecting-rods. The superior scavenge of the opposed piston engine permits of the use of a minimum weight of scavenge air per unit of fuel burnt, thus giving a higher exhaust temperature than is obtained with the return scavenge system of normal two-stroke cycle engines, and rendering the opposed piston engine peculiarly suitable for use in conjunction with waste heat boilers. In the proposed engine the exhaust manifold is arranged underneath the cylinders and is thus in a convenient position for the installation of waste heat boilers at the tank top level, thus avoiding the objectionable features of heavy boilers located at a considerable height in the ship, and possibly occupying valuable upper deck space. The main guides are of the trunk piston type, and it is believed that, in the horizontal cylinders, it will be more easily possible to prevent, or, at any rate, to reduce to negligible limits, the contamination of the engine-forced lubrication system by carbonised cylinder lubricating oil and burnt gas, and the access to the cylinders of lubricating oil from the crank cases, which are regarded as serious defects in the vertical type of trunk piston engine. Details of the piston construction are not indicated, but it is probable that they will be of the composite type, with forged steel or alloy heads, oil-cooled, and provided with internal arrangements for intensive circulation designed to promote the efficient transfer of heat from the internal surfaces and the prevention of the formation and adhesion of carbonised deposits, the supply and discharge arrangements being such as to retain a full charge of cooling oil in the pistons at all rates of oil delivery. The cylinder liners are also of the composite type, the liners proper being of cast iron, secured by flanges to a central combustion chamber of cast steel, in which are formed the necessary pockets for the fuel, starting air, relief and indicator valves. The portions of the liners which are of cast iron are thus plain, relatively thin, flanged tubes, unpierced by openings of any description likely to originate cracks, and free from irregularities of section which might prove to be the source of incipient weakness in the zone of maximum temperature. The composite construction also avoids the difficulties associated with the growth of continuous cast iron liners in the central portion which is not traversed by the piston rings. Provision is made for intensive cooling of the combustion chamber and individual cooling of the exhaust port bars.

Scavenge Pumps.—As shown in Fig. 2 the scavenge pumps are of the opposed piston, double-acting type, the pistons themselves being of light alloy with cast iron rims. Two light alloy mechanically

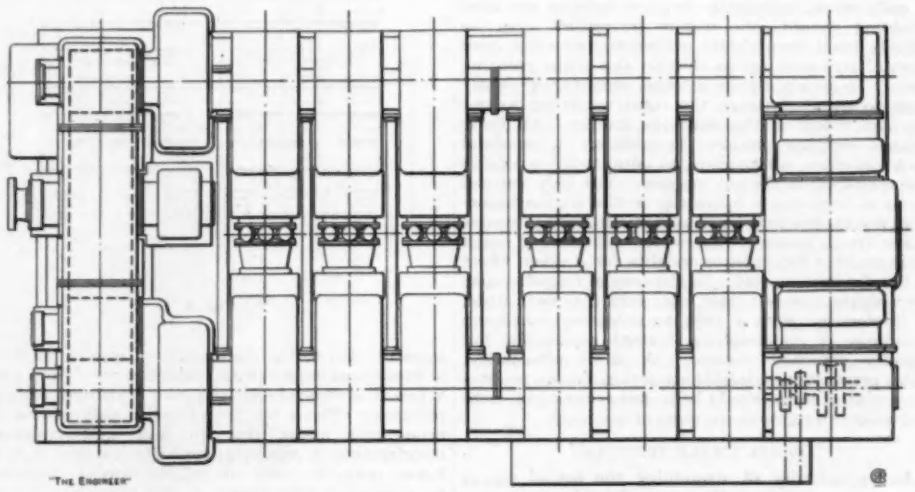


FIG. 3—PLAN OF PROPOSED SIX-CYLINDER OPPOSED-PISTON ENGINE

operated rotating valves, of the type rendered familiar by the Worthington and Richardsons-Westgarth engines, serve to regulate the intake and discharge of air from both cylinders, the suction valve being arranged above the pumps and the delivery valve below. Operation of the valves is effected by a positive chain drive from one of the crank shafts, reversal being accomplished by a vertical movement of translation of the jockey pulleys, which are mounted upon a slide suitably connected with the main reversing gear. In order to avoid the occurrence of excessive pressures in the scavenge pump cylinders during periods of manœuvring, the pumps are provided with large relief valves communicating with the end suction ports, and with others communicating with the space between the opposed pistons.

Alternatively, the pistons themselves may be of the bucket form provided with spring-loaded valves which normally remain closed, but are so arranged

as to by-pass the air from side to side of the pistons in the event of excessive pressures arising.

Fuel Supply and Manœuvring Arrangements.

The fuel supply and manœuvring arrangements are conveniently grouped in a centralised unit, as shown in Figs. 2 and 3. Airless injection is employed, there being one fuel pump of the impulse displacement type for each engine, and one automatic fuel injection valve at the top of each cylinder. For an engine fitted with only one fuel valve per cylinder, the diameter of cylinder employed may be considered as unduly approaching the limit. The low compression ratio possible in quick-running opposed piston engines, however, combined with the advanced timing necessary for high-speed operation, will facilitate initial penetration, and hence a sufficiently uniform distribution of fuel in the combustion chamber, and should thus go far to justify the employment of a single fuel valve. In the larger cylinders of engines of much higher power, the provision of two or more fuel valves would be necessary. In such engines, however, the space between the cylinders and the tank top would be sufficient to render fuel valves on the underside of the cylinders readily accessible.

It will be noted that in this type of engine, although virtually two engines are geared to each propeller shaft, the question of the synchronisation of the manœuvring operations of two independent units does not arise.

Balance.

The unbalanced forces produced by the reciprocation of each piston and the appropriate portion of its connecting-rod will be neutralised, in virtue of the opposed piston arrangement, by those arising from the simultaneous reciprocation, in unison with, but in the contrary direction, of their opposite numbers, and there will thus be no free primary or secondary force or moment in the horizontal plane due to the main engine reciprocating parts. In the same way, the reciprocating parts of the opposed piston scavenge pumps will also be in complete balance. The forces operating will cause sinuous horizontal movements—symmetrical about a fore and aft plane central between the crank shafts—of the engine framework, due to the alternate extensions and compressions they produce. Such movements are, however, unavoidable, since they must necessarily arise in response to the variations of gaseous pressure within the cylinders. With the cylinders symmetrically disposed, and cranks arranged at 60 deg., firing order 1, 6, 2, 4, 3, 5, there will also be no free force or moment in any plane due to the revolving parts. In the absence of balance weights, however, the engine framework would be exposed to deflections rotating about the crank shaft centres, due to the transmission of the dynamic forces involved. In the horizontal plane these deflections would be compounded with, and in some cases accentuate, those induced by the reciprocating parts and variations in piston load. By fitting balance weights at each crank, sufficiently large to balance the total revolving weight, the engine framework may be entirely freed from elastic deformations arising from internal dynamic forces due to the main rotating parts. To give complete balance, weights sufficiently large to counterbalance the total revolving weight are also fitted at the scavenge cranks. All these balance weights produce, in addition, a beneficial fly-wheel effect, although in an admittedly expensive and relatively inefficient manner. The only vertical forces of importance operating on the engine framework would thus be those caused by the guide pressures of the trunk pistons. The semi-built form of crank shaft enables the balance weights for a given effect to be of minimum size. In the case of forged cranks the weights may be forged solid with the crank webs, or, preferably, with a view to obtaining maximum soundness of construction, formed separately and suitably attached thereto. A third alternative, which presents considerable attractions from a production point of view, would be to form crank pin, webs and balance weights in one piece of cast steel.

Torque Characteristics.

An opportunity of examining the actual torque characteristics of the engine, as modified by the inertia of the reciprocating parts at high speed, has not yet presented itself; but a useful approximate comparison based on published figures, is possible. Table II., giving the torque characteristics of vertical single-acting engines, is abstracted from a paper on "Some Aspects of Diesel Engine Design" by D. M. Shannon, read before the Institution of Engineers and Shipbuilders in Scotland in April, 1912.

Table II.

No. of cranks.	Crank angles	Order of firing.	Cycle.	Ratio of maximum to mean torque. Inertia in lb. per sq. in. of piston area. 0	100	200
6	Deg. 120	1, 2, 3, 6, 5, 4,	Four-stroke	2·42	1·44	2·02
6	120	1, 5, 3, 6, 2, 4	,,	2·42	1·44	2·02
8	90	1, 5, 2, 6, 4, 8, 3, 7	,,	1·74	1·61	1·63
8	90	1, 6, 2, 4, 8, 3, 7, 5	,,	1·74	1·61	1·63
6	60	1, 6, 2, 4, 3, 5	Two-stroke	1·12	1·17	1·17
6	60	1, 4, 5, 2, 3, 6	,,	1·12	1·17	1·17
8	45	1, 7, 5, 4, 2, 8, 6, 3	,,	1·03	1·02	1·01
8	45	1, 8, 6, 4, 2, 7, 5, 3	,,	1·03	1·02	1·01

W. S. Burn, in a paper on "High-powered Oil Engines," read before the North-East Coast Institution of Engineers and Shipbuilders in April, 1926, gives the ratio of maximum to mean torque for a six-cylinder vertical double-acting, two-stroke cycle engine running at 90 revolutions per minute as 1·2. The engine had cylinders 26½in. diameter and 47½in. stroke, with a total reciprocating weight of 13,664 lb., the inertia per square inch of cylinder area thus being 132 lb.

Assuming a three-cylinder, double-acting, four-stroke cycle engine to be roughly equivalent to a six-cylinder, single-acting one, the above particulars cover all the types of engines instanced in Table I., those which up to the present have only been used in conjunction with hydraulic clutches being included, in view of the possibility of their being employed in rigidly-connected geared units also.

The torque characteristics of the proposed horizontal opposed-piston engine would be comparable with those given in Table II. for six-cylinder, two-stroke cycle, single-acting engines. Its actual characteristics would probably be relatively slightly superior, due to the elimination of gravity effects in a horizontal engine with balanced revolving parts. When it is remembered that the maximum torsional resistance offered by the propeller may exceed 1·1 times the mean, due to hull and appendage interference, it would appear that, apart from the lower periodic time of engine torque variations as compared with those of the propeller, and the length of the propeller shaft compared with those connecting the engines with the pinions, the torque characteristics of the proposed engine, considered in respect of its use in conjunction with gearing, are reasonably good, independently of the damping effect of the fly-wheels and balanced cranks. In a related connection, it may be mentioned that the lubrication difficulties encountered in slow-speed, single-acting. two-stroke cycle engines are greatly minimised in those operating at high speeds, particularly when of the horizontal type.

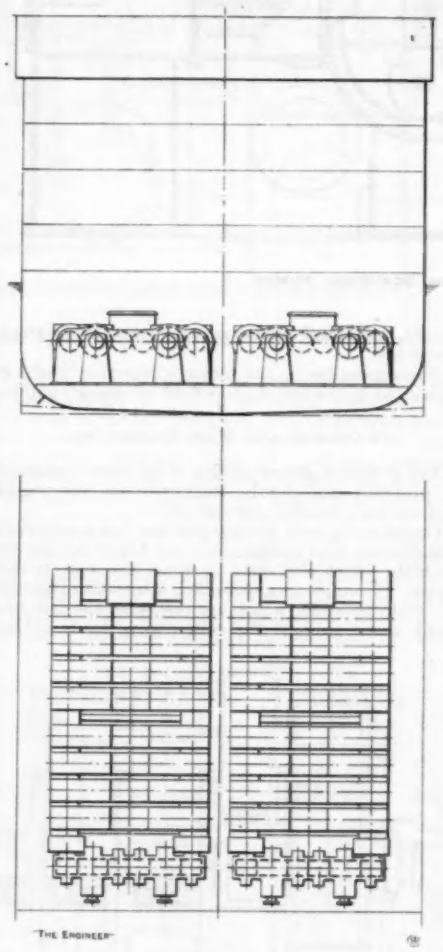


FIG. 4

Space Requirements, Modified Arrangements and Probable Field of Application.

From Figs. 1, 2 and 3 it will be apparent that the horizontal opposed-piston geared Diesel engine is very economical of space generally, and markedly so in the vertical direction. The latter feature is of especial value in merchant vessels of the liner class, and will render this type of engine particularly suitable for naval purposes if, as appears to be probable from the example of the German cruiser "Ersatz Preussen," the geared unit is the form in which internal combustion engines are ultimately to be applied for the propulsion of armoured vessels. The horizontal opposed-piston internal combustion engine also appears to offer considerable advantages in regard to the conversion of existing geared turbine steamships. In the engine illustrated in Figs. 1, 2 and 3, the two crank shafts are interconnected by the minimum number of gear wheels it is possible to use for the purpose in view, an arrangement which, in the majority of cases, would naturally be adopted on the score of simplicity.

Under special circumstances, however, the wheels constituting the interconnecting train may be of any convenient even number from two upwards, the case in which two wheels only are employed, of course, being that in which the engine and propeller speeds are equal.

Thus, Fig. 4 illustrates in diagrammatic form a scheme for a quadruple screw liner, in which a very conservative gear ratio is employed, *i.e.*, the prime movers hardly fall into the category of high-speed engines, but advantage has been taken of the geared system to adopt a relatively low speed of propeller revolutions.

The following are the approximate particulars :—

Number of engines	2
,, propellers	4
Total B.H.P.	12,000
Revs. per min. of propellers	100
,, ,, engines	150
Number of cylinders in each engine	8
Diameter of cylinders	600 mm.
Combined stroke	1,520 mm.
Brake mean pressure	76 lb. per sq. in.
B.H.P. per sq. in. of area of pistons	0·8575
Approximate piston speed	750ft. per min.
Diameter of propellers	15ft.
Approximate centres of inner propellers	19ft. 7in.
,, ,, outer propellers	46ft. 5in.
,, ,, crank shafts	23ft.
,, diameter of main gear wheels	5ft. 9in.
,, ,, pinion and idlers	3ft. 10in.

In this case each train of gears consists of two main gear wheels mounted on the propeller shafts, two pinions coupled to the crank shafts and two intermediate idlers. In this particular installation, the pinions and idlers have been arranged of the same diameter in order to simplify the questions of production, renewals and spares. The centres of the propeller shafts may be brought below the level of the crank shafts by suitable modifications to the diameters of the gears if necessary. The engines are of the crosshead type, and scavenging is effected by means of two double-acting pumps arranged outside of and in tandem with two opposed piston pumps similar to those shown in Fig. 2, the outer double-acting pumps being of somewhat larger diameter than the opposed-piston pumps. The maximum height of the engines above the tank top would be about 13ft. 6in. It will be noted that the inner propellers turn outwards and the outer propellers inwards, when going ahead, a fact which would require to be borne in mind in designing the appendages. On reference to Table II., it will be seen that the torque characteristics of an engine of this type are particularly favourable, so much so, in fact, that it is probable that the crank shaft balance weights will provide nearly all the fly-wheel effect necessary, apart from the question of avoiding negative torques in the operating range due to torsional criticals.

For use in shallow draught vessels, a similar arrangement, by which one engine is arranged to drive twin screws of relatively small diameter, might be adopted. Both propellers would necessarily operate simultaneously in the same direction, *i.e.*, it would not be possible to run one propeller ahead and the other astern in manœuvring. If fitted with non-reversing hydraulic clutches, however, one propeller could be trailed while the other was working by emptying the appropriate clutch, while, if fitted with reversing clutches, the full manœuvring capabilities inherent in twin-screw installations may be obtained.

In applying the engine to the field of oil engine-electric propulsion, a number of alternative arrangements are available. A single full-capacity generator could be directly coupled to one of the crank shafts. In this case it would probably be convenient to make both the intermediate wheels, which would be idlers, of the same diameter. Alternatively, the two intermediate wheels might be made of different diameters with respect both to each other and to the equal pinions on the crank shafts, and the generator coupled to one of them, with the object of varying the speed of the generator in relation to the speed of the engine. With equal generator and engine speeds, the whole of the four inter-connecting gear wheels may be of the same diameter, and the generator coupled to any one of them, as considerations of space and convenience dictate.

Provided the electrical difficulties associated with the running of two generators in a rigid mechanical phase relationship can be successfully negotiated, a separate generator might be coupled to each of the two crank shafts. The functions which would devolve upon the train of gearing by which the two shafts were interconnected would then be merely nominal, and the scantlings of the gearing could be reduced accordingly. If designed to transmit one-fourth of the total power, it would be possible to take one generator off

the circuit, leaving it to revolve idly while the other was driven by the engine at reduced power. Other possible arrangements of horizontal opposed-piston geared oil engine generating sets will readily suggest themselves.

Vertical Opposed-piston Geared Oil Engines.—It is obvious that, in cases in which the vertical height conveniently available in relation to the dimensions of individual units is sufficiently large, the design shown in the figures may be readily adapted to one in which the axis of the cylinders is vertical. Such an arrangement would give a geared design which is very economical in regard to athwartship width, and thus suitable for use where a number of units are arranged abreast, as in triple and quadruple-screw vessels.

The Automatic Stabilisation of Ships.

No. X.*

IN Fig. 29 there is illustrated, by courtesy of the makers, Swan, Hunter and Wigham Richardson, Ltd., the gyroscopic equipment on the Schlick system, which was built in 1908 and installed first on the MacBrayne steamer "Lochiel" and later on the "Dirk," a smaller vessel belonging to the same owners. The "Lochiel" was a single-screw steamer measuring 135ft. on the water line with a breadth of 22ft. and a mean draught of 9ft. 9in. The gyroscope equipment was placed on the double bottom of a hold forward of the engine and boiler room, and occupied a floor area of something less than 6ft. by 6ft. The gyroscope wheel had a diameter of about 4ft., weighed 3 tons, and was driven electrically at about 1800 r.p.m. by a 10 horse-power motor. As the engraving shows, the wheel was contained inside a housing which was mounted to swing on athwartship bearings. The wheel, the wheel casing and its adjuncts were so designed that the common centre of gravity lay below the athwartship axis. This arrangement gave precisely the effect supplied by the weight W indicated in Fig. 28. As we have already pointed out, a fixed weight at a fixed distance beneath the transverse axis of the gyroscope can give the precessional moment requisite for complete stabilisation only under one particular set of wave conditions, and even then can only do so approximately. Under other than the particular wave conditions, therefore, the gyroscope requires a precessional control additional to that provided by the fixed weight. Schlick supplied this additional control by means of a hand-operated circumferential brake on the casing. This brake is clearly shown in the engraving. We have no information as to the total weight of the wheel and its casing, or as to the distance of the centre of gravity of the whole equipment beneath the precessional axis.

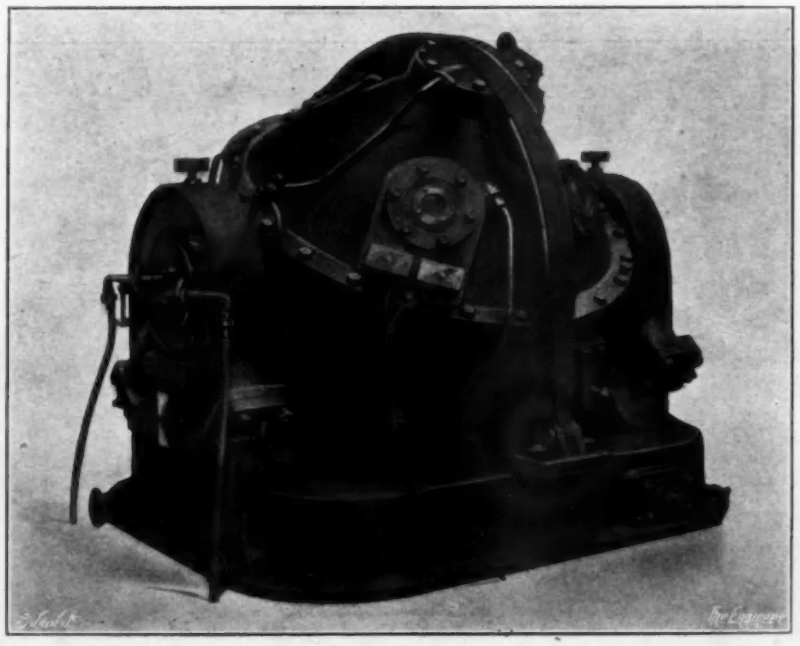


FIG. 29—SCHLICK STABILISER FOR R.M.S. "LOCHIEL"

In Fig. 30 there is shown a cross section of the Schlick equipment fitted to the ex-German torpedo-boat destroyer "See-bar" This vessel had a length of 116ft. and a displacement of 56·2 tons. The stabilising equipment was placed forward of the boiler space, about a third of the vessel's length from the bow. The wheel, a metre in diameter, weighed 1106 lb., and was driven at a normal speed of 1600 r.p.m. by steam. The steam supply was admitted through one of the hollow athwartship trunnions and was exhausted through the other. It drove the wheel by impinging on rings of blades mounted on the wheel periphery. The casing was steam-tight, and in effect formed with the fly-wheel a steam turbine. The common centre of gravity of the wheel and casing was arranged to lie below the trunnion axis, but again information is lacking as to the magnitude of this distance and the weight of the casing.

The particulars which have survived of these two examples of the Schlick system and of the vessels concerned are not sufficient to enable us to examine them fully as illustrations of the application in practice of the principles of gyroscopic stabilisation. In a paper presented before the Institution of Naval Architects in 1904, however, Herr Schlick gave full particulars of a gyroscopic equipment designed for a hypothetical vessel. From that paper we take the following figures:—

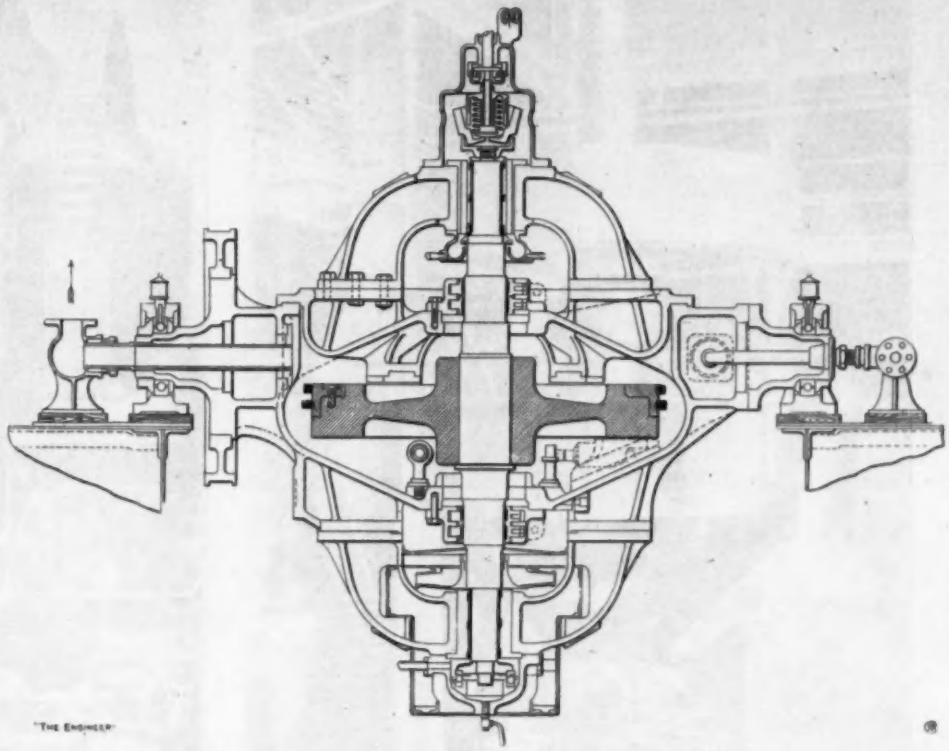


FIG. 30—SCHLICK STABILISER FOR DESTROYER "SEE-BAR"

Schlick Equipment for a 6000-ton Ship.

Displacement of vessel	5905·5 tons
Metacentric height	17½in.
Double roll period	15 sec.
Diameter of fly-wheel	13·12ft.
Weight of fly-wheel	9·842 tons
Peripheral speed	656ft./sec.
Total weight of wheel and frame	20 tons
Distance of centre of gravity of wheel and casing below line of trunnions	(*a*) 19½in. (*b*) 39½in.

It was no doubt desirable from Herr Schlick's point of view to impress British shipbuilders and owners with the simplicity of his stabilising equipment, and the small additional weight involved by its adoption. He therefore selected a low, but not absurdly low, value for the metacentric height of his hypothetical vessel. A small metacentric height means a small heeling moment, and therefore a small gyroscope. He also adopted a high peripheral speed for the wheel, because the higher the speed the smaller is the size of the wheel required to produce a given gyroscopic "power," *é* I. In the discussion, his attention was called to the fact that the peripheral speed of his wheel corresponded to a centrifugal tension of about 21 tons per square inch, and that whatever might be the case in Germany, he would find difficulty in persuading British Board of Trade surveyors to pass such a wheel as safe.

No attention was called to a third feature of the data—the lowness of the weight assigned to the wheel. A plain steel disc 13·12ft. in diameter and weighing 9·842 tons, would have a thickness of only 4in. If we suppose, as is reasonable, that the wheel was to be similar in its proportions to that actually designed for and used at a subsequent date in the "See-bar," then the diameter and weight given by Herr Schlick indicate the employment of a metal weighing 96 lb. per cubic foot; that is to say, a metal having only 60 per cent. of the weight of aluminium. A steel wheel 13·12ft. in diameter and similar in proportions to that employed in the "See-bar" would weigh 50·44 tons, or more than five times as much as the weight assigned by Herr Schlick to the wheel required for the stabilisation of his hypothetical vessel.

It is of interest to note that the formula established in article No. VIII. indicated quite definitely that a wheel of the size and weight specified by Herr Schlick would completely fail to stabilise the vessel considered, on waves amounting to anything more than ripples, and that one weighing round about 50 tons would, in actual fact, be necessary. Assuming (*a*) that the wheel has the proportions of that used in the "See-bar," (*b*) that the peripheral speed is 656ft. per second as specified by Herr Schlick, and (*c*) that on the standard wave—T=6·28 sec., L=200ft., H=10ft.—the oscillation of the gyroscope is 30 deg. on each side of the vertical, then, calculating in the manner previously indicated, we find that the wheel required would be one having a diameter of 12·48ft. and a weight of 43·4 tons. Had we selected the angle of oscillation on the standard wave at 22 deg. instead of 30 deg., the wheel required would have been one 13·12ft. in diameter and weighing 50·44 tons.

It is curious to note that although Herr Schlick clearly mis-stated the weight of the wheel required to stabilise his hypothetical vessel, the value which he gave for the precessional moment, namely, that contributed by a weight of 20 tons at a distance of 19½in. below the precessional axis, is substantially correct if the true wheel weight is substituted for the inaccurate one. Our approximate method of calculation shows, assuming as before that the two moments of inertia, I′ and I, are equal, that the precessional moment required to give complete stability is one rising from zero up to a maximum of 17·2 tons-feet. A weight of 20 tons lying at a distance of 19½in. beneath the precessional axis would, when the deflection was 30 deg., contribute a moment of 16·4 tons-feet.

It is clear that subject to the correction of what

* No. IX. appeared May 30th.

THE SPERRY SYSTEM OF GYROSCOPIC STABILISATION

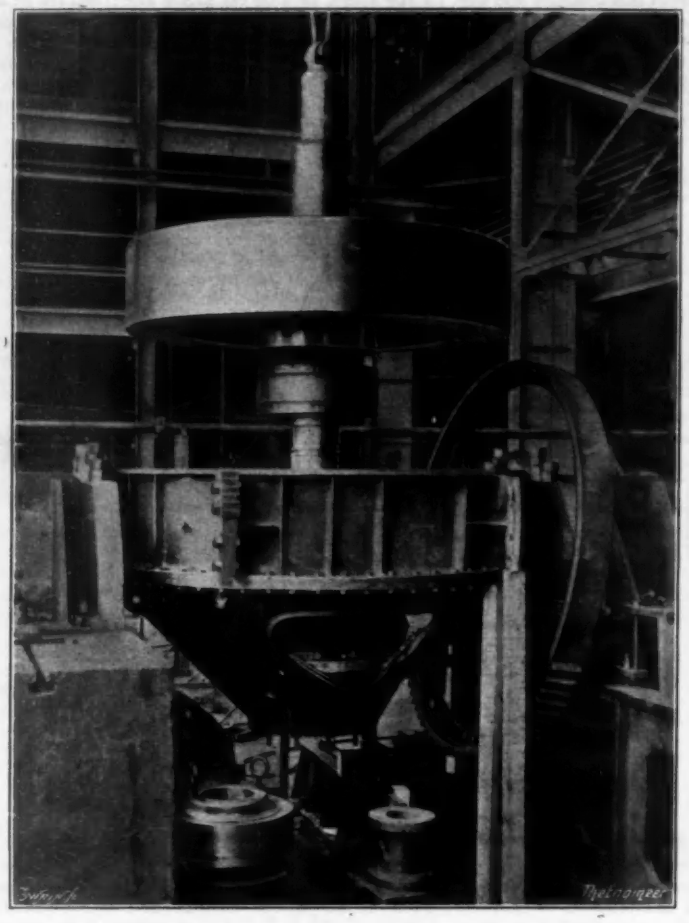


FIG. 31—WHEEL AND CASING UNDER ASSEMBLY

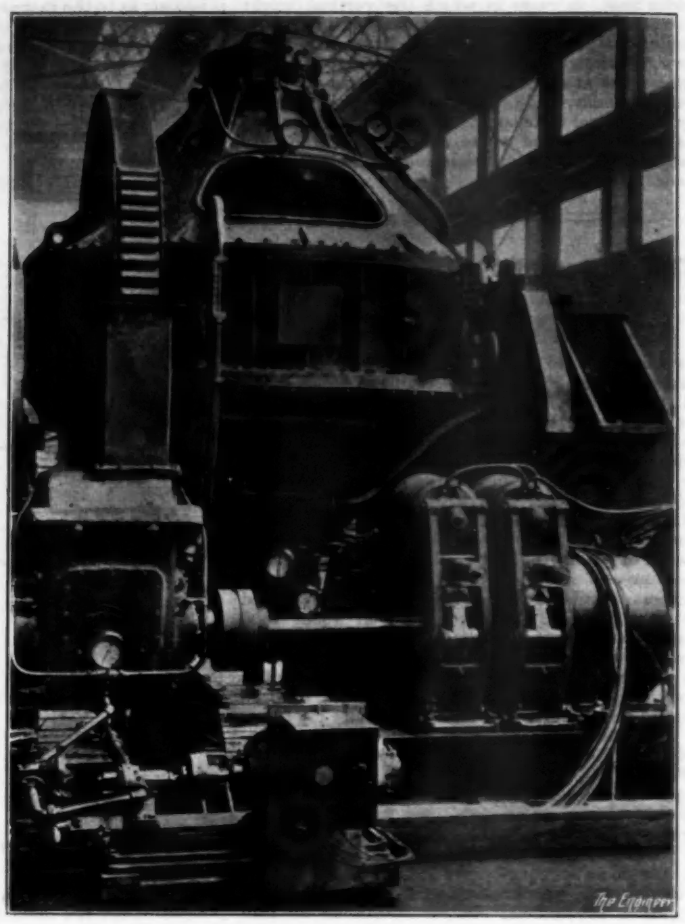


FIG. 32—COMPLETE EQUIPMENT ERECTED FOR TESTING

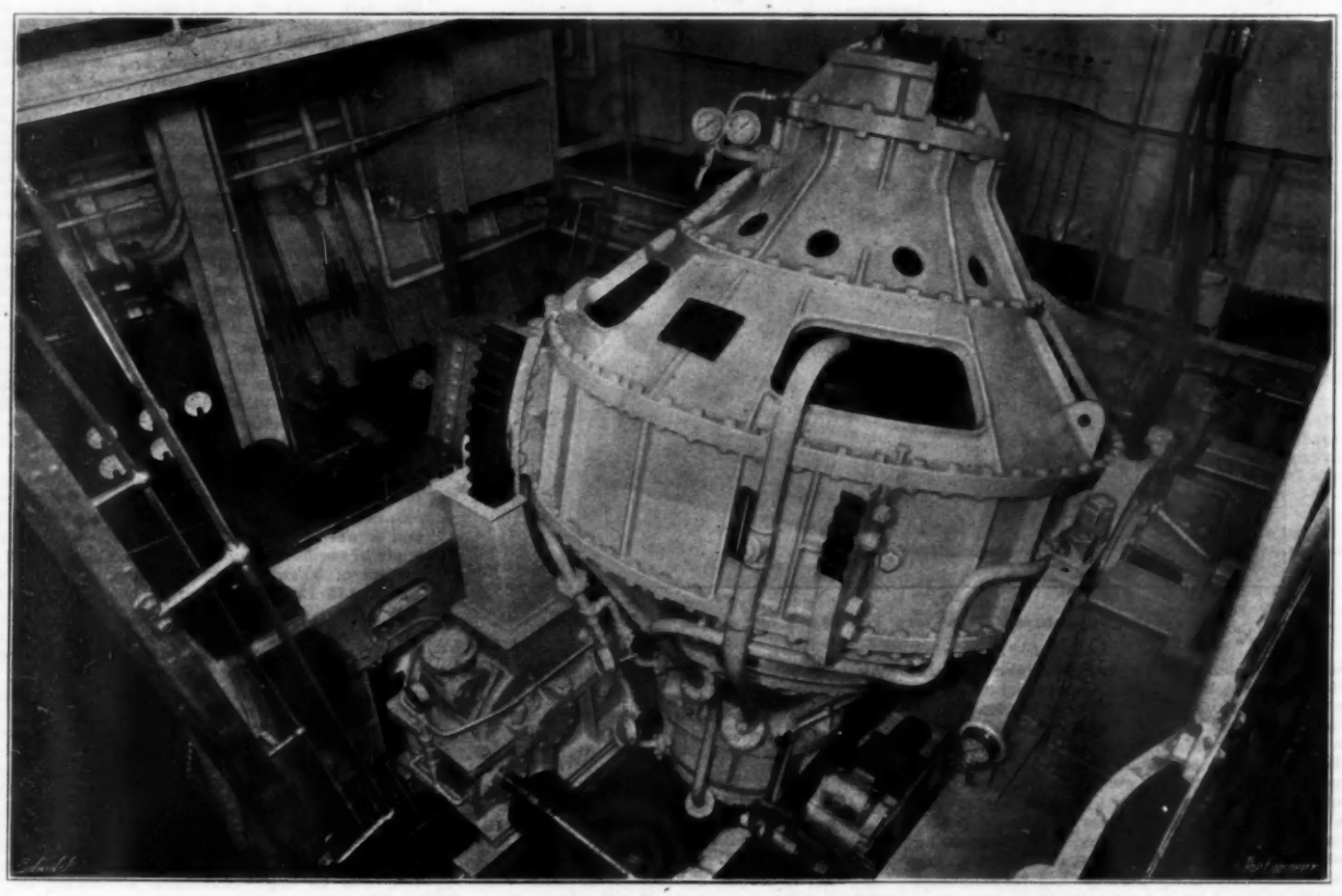


FIG. 33—STABILISER INSTALLED IN A PLEASURE YACHT

we may suppose to be a slip in the statement of the weight of wheel required, the data given by Herr Schlick are in agreement with the requirements for complete stabilisation, as indicated by our analysis of the problem. The Schlick system was unsatisfactory, not because of any miscalculation, but because the use of a fixed weight at a fixed distance as a means of supplying the required precessional moment was wrong in principle. We have shown that it must lead to excessive, or insufficient, oscillation of the gyroscope except under one particular set of wave conditions, and that a friction brake as a means of reducing the oscillations when they were excessive would provide only a partial remedy. In practice a skilled man had to be in constant attendance at the brake and, as a consequence, the device completely lost its intended automatic character. Sufficient was, however, done to show that stabilisation by means of a gyroscope could be made effective, and had Herr Schlick lived it is probable that from the experience obtained with the "See-bar" and the "Lochiel" he would eventually have evolved a practicable system. As it was, the development of the idea was taken up by the Sperry Gyroscope Company of America. We believe we are correct in saying that this company purchased one of the two Schlick stabilisers that had been made by Messrs. Swan, Hunter. It did not, however, endeavour to perfect the Schlick principle, but instead struck out on a line of its own characterised by a new method of controlling the precession.

A diagram of the Sperry system is given in Fig. 34 and in Figs. 31, 32 and 33 photographs of actual installations are reproduced. The stabilising or main gyroscope is mounted inside a casing, which, as usual, is supported to turn on a horizontal, athwartship precession axis. The wheel is spun on its axle by current derived from a turbo-alternator supplying a three-phase motor of which the rotor is mounted on the lower portion of the fly-wheel axle, while the stator is fixed inside the wheel casing. In order to reduce the power spent in maintaining the wheel in rotation the casing is exhausted to a vacuum of about 24in. of mercury.

Fixed externally to the casing concentrically with the precession axis is a toothed segment. This segment meshes with a pinion geared to the shaft of a direct current precession motor with which an electrically operated brake is connected in series. The supply of current to the precession motor is given through a reversing switch, the throwing over of which is governed by a small control or pilot gyroscope. It is to be noted that while the diagram as a whole shows the equipment as seen looking fore and aft, the control gyroscope for the sake of clearness is shown in plan. The equipment is completed by a "stabilising and rolling switch," whereby the action can be changed over from the normal one of stabilisation to one in which the main gyroscope can be used to roll the vessel in the absence of waves.

The outstanding feature of the system, it will be observed, is that the stabilising gyroscope is not free to precess naturally on the athwartship axis under the action of the heeling moment applied by the waves. The precession is effected artificially by the precession motor. The control gyroscope is very sensitive to the heeling moment applied to the ship by the waves and under the influence of that moment it precesses in one direction or the other and closes one or other of the contacts indicated at the end of its axle. Thereupon, one or other of the coils of the reversing switch is energised, the circuit of the precession motor is completed and that motor is started up in the corresponding direction. As a result the main gyroscope is forcibly precessed about the athwartship axis in the direction which will cause the gyroscopic reaction, produced by the precession, to oppose the heeling moment of the waves. The brake, combined with the precession motor, is normally "on." Its coils are, however, in series with the precession motor. Consequently, as soon as that motor is started up the brake is pulled off magnetically and the precession motor is free to exercise its full power on the toothed segment.

As time goes on the heeling moment applied to the ship by the waves falls off. Before it becomes quite zero its effect on the control gyroscope will be insufficient to maintain the electrical contact established by that gyroscope. Centralising springs thereupon pull the axle of the control gyroscope into the mid position, and as a result of the action of the reversing switch current will be cut off from the precession motor. Simultaneously, it will be cut off from the coils of the brake, which, as a consequence, becomes operative to stop the precession motor, and therefore the precession of the main gyroscope. The stabilising reaction vanishes with the disappearance of the precession, as it should in accordance with the fact that the heeling moment is zero or just about to become zero.

Immediately afterwards the heeling moment begins to build up in the reverse direction. The control gyroscope at once detects it and precesses to close the second contact at the end of its axle. The reversing switch is thereupon thrown over, the brake is once more pulled off and the precession motor is started up in the opposite direction. As a result the main gyroscope is precessed back towards the vertical and develops a reversed reaction corresponding to the reversed direction of the heeling moment. The precession of the main gyroscope continues beyond the vertical until the heeling moment again becomes so small that the control gyroscope cannot maintain its position against the action of the centralising springs. Once again current is cut off from the precession motor and the brake is applied to stop that motor and the precession of the main gyroscope. The cycle is completed when the heeling moment reverses and causes the control gyroscope to reclose the first contact at the end of its axle. This action once more releases the brake, starts up the precession motor and leads to the main gyroscope being precessed back to the vertical position.

We have seen that a simple gyroscope mounted on an athwartship axis in a vessel will precess with an angular velocity ϕ determined for it by the magnitude of the heeling moment M applied to the ship by the waves, the value of this precessional velocity being given by $\phi = M\,g/\dot{\phi}\,I$. In the Sperry equipment the main gyroscope feels the heeling moment just as much as does the control gyroscope. It is not, however, allowed to develop the corresponding natural precessional velocity. Its precessional velocity is determined for it by the speed given to the precessional motor. That speed is not varied to suit the magnitude of the heeling moment, but is substantially constant at a value selected by the designers of the equipment. It is quite possible that the ship may encounter a wave the heeling moment of which would induce in the gyroscope, if free, a precessional velocity greater than the precessional velocity determined by the speed of the precession motor. In its effort to precess at its natural rate the main gyroscope in these circumstances will act to drive the precession motor instead of submitting to being driven by it. The motor will thereupon become a generator and will develop a back E.M.F. opposing the pressure of the supply current. The current through the brake coils will

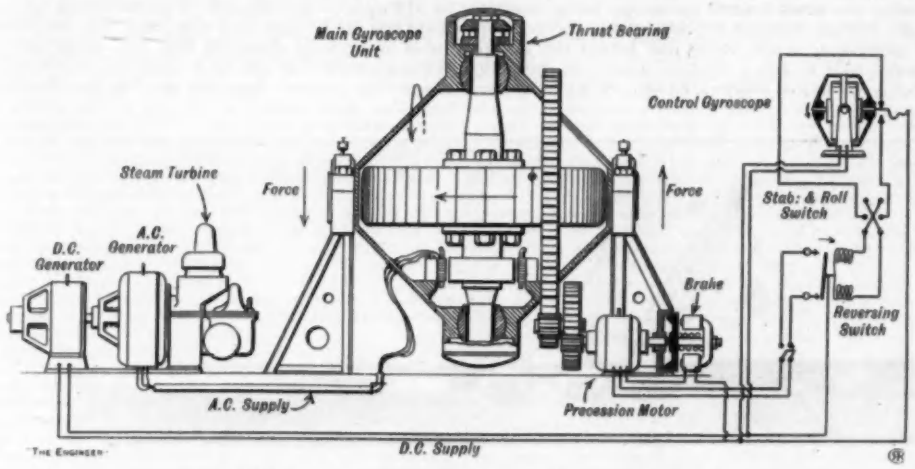


FIG. 34—DIAGRAM OF THE SPERRY STABILISING EQUIPMENT

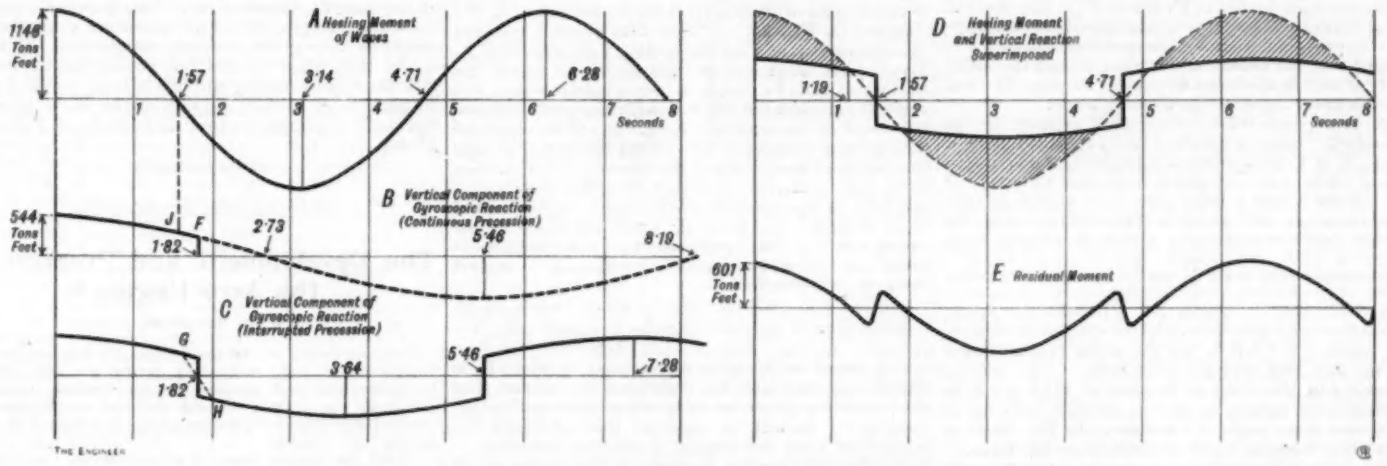


FIG. 35—THEORETICAL ACTION OF THE SPERRY STABILISER ON A "STANDARD" WAVE

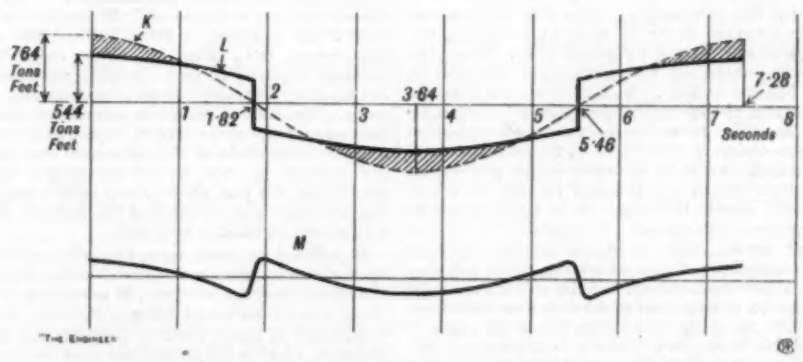


FIG. 36—ACTION OF SPERRY STABILISER ON A MODIFIED WAVE

therefore be diminished, the brake will come into action and the precession of the main gyroscope will be checked down to the value set by the designed speed of the precession motor. In practice this regenerative action results in the speed of the precession motor remaining constant to within about 5 per cent. under all conditions.

The theory of the Sperry stabiliser can be easily followed from a numerical example. For a vessel having a displacement, w, of 4500 tons, a metacentric height, h, of 1·62ft., and a natural rolling period of 12 sec., the wheel used has a moment of inertia, I, of 620,000 in pounds and feet and a speed of spinning of 1050 r.p.m., corresponding to an angular velocity $\dot{\theta}$ of 110 radians per second. The speed of the precession motor is such as to give the gyroscope a precessional velocity—substantially constant under all conditions—of 0·575 radian per second. This value is selected in accordance with a semi-arbitrary rule that the precessional velocity should be that given by the formula $\phi = 2 \cdot 2\,\pi/T'$, where T′ is the natural rolling period of the ship to be stabilised. An arrangement is provided whereby the precessional motor is stopped and the brakes are applied should the angle of tilt at any time exceed 60 deg. or 70 deg. We will take the lower figure as the limiting angle.

Let us suppose that this vessel is exposed to our "standard" train of waves, a train, that is, having a period, T, of 6·2832 seconds, a length L from crest to crest of 200ft., and a height H from crest to trough of 10ft. If the vessel is fully stabilised—that is to say, if she rides over the waves without heeling from the vertical—she will experience a heeling moment from the waves given by $w\,h\,\pi\,\frac{H}{L}\cos\frac{2\,\pi}{T}\,t$. This is the formula established in article No. VI. with the metacentric height h substituted for its equivalent $b^2/12\,d$. The quantity $w\,h\,\pi\,H/L$ has the value 1146 in terms of tons and feet and $2\,\pi/T$ is unity. The heeling moment can therefore be written as 1146 cos t, in which t is the instant of time in seconds and cos t is the cosine of an angle of t radians. In Fig. 35 at A the heeling moment curve is shown on a time basis.

Since the precessional velocity is constant, the gyroscopic reaction is also constant. It is given, as we know, by $\dot{\theta}\,\phi\,I/g$, which, for the equipment being considered, has the value 544 tons-feet. This reaction is developed about the diameter of the fly-wheel at right angles to the athwartship axis, about an axis, that is to say, which is originally horizontal in the fore-and-aft direction, but which tilts with the precession. The force available for balancing the heeling moment of the waves is the vertical component of the gyroscopic reaction. This vertical component at any instant t will be $544 \times \cos\varphi$, where φ is the angle of tilt acquired by the gyroscope. Since the precessional velocity is constant at 0·575 radian per second, the angle of tilt at any instant t will be $0 \cdot 575\,t$. Hence the vertical component of the gyroscopic reaction is given by 544 cos $0 \cdot 575\,t$. In Fig. 35 curve B represents the value of the vertical component as given by this formula. The curve is drawn on the supposition that the precession is continuous in the one direction.

At an angular velocity of 0·575 radian per second the gyroscope would tilt through 90 deg. in about 2·73 seconds, and in that position its reaction would have no vertical component. Thereafter the vertical component would grow up in the reverse direction as the gyroscope tilted beyond 90 deg. up to 180 deg. Actually, as has been stated, the tilt of the gyroscope is restricted to a maximum of 60 deg. away from the vertical. At the given rate of precession an angle of 60 deg. would be reached in about 1·82 seconds. We therefore stop the curve at the point F, the vertical line from which indicates that the precession has been interrupted at this instant, and therefore that the gyroscopic reaction has been made to vanish.

If when the gyroscope had tilted through 60 deg. its precession could be instantaneously stopped and instantaneously started again in the reverse direction, the vertical component of the gyroscopic reaction would be that represented by the curve C, which is built up of repetitions of the curve B up to the point F. The fact that it is not possible to stop and start a moving body instantaneously may be represented by joining the portions of the curve by sloping lines, as at G H, indicating that the precessional velocity and therefore the vertical component of the gyroscopic reaction vanishes and reappears in the reverse direction, not suddenly, but relatively in a gradual manner.

The interruption of the precession at a tilt of 60 deg. represents the limit of action of the gyroscope. If this angle is just reached, the gyroscope is working up to its full capacity. In the example we are considering the small control gyroscope being sensitive to the heeling moment applied by the waves, stops the precession motor at or just before the heeling moment falls to zero; that is to say—as shown by curve A—at or just before 1·57 sec. At a precessional velocity of 0·575 radian per second, the gyroscope in 1·57 sec. would tilt through an angle of about 52 deg. It would therefore be working within its capacity.

The interruption and reversal of the precession at 1·57 sec. gives a vertical reaction curve composed of repetitions of the curve B up to the point J. In diagram D, Fig. 35, we show this vertical reaction curve superimposed on the heeling moment curve A. The shaded areas indicate the extent to which the equipment fails to supply a gyroscopic reaction, the vertical component of which would completely stabilise the vessel on the standard wave. It will be observed that at certain instants the vertical reaction is greater than the heeling moment of the waves, and is therefore more than sufficient to impart complete stability to the ship. The magnitude of the excess and the period of its duration are, however, small relatively to the excess and duration corresponding to the instants at which the vertical reaction is insufficient to impart complete stabilisation.

The residual moment—that is to say, the moment remaining to be supplied in order to impart complete stability to the ship—is the difference between curves shown at D, and is represented by curve E, in which some allowance has been made for the fact that the precession cannot be stopped and restarted instantaneously. It will be observed that although the equipment does not supply a reaction sufficient to counteract the heeling moment of the waves at all instants, it reduces and modifies very materially the heeling moment curve. The vessel will roll, but the magnitude of her movement will be materially reduced. Furthermore, the effective heeling moment is broken up in a manner which is clearly inimical to the establishment of any synchronism between the action of the waves and the natural rolling of the vessel.

As the wave conditions depart from those of our "standard" train, the effectiveness of the stabilisation given by the equipment changes. If, for example, the waves have a period of 7·28 seconds, a length of 270ft., and a height of 9ft., then for the same ship the curves K L, Fig. 36, show respectively the moment required to give complete stabilisation and the moment supplied towards that end by the gyroscope. The lack of complete agreement, as shown by the residual moment curve M, is, it will be seen, small, and the magnitude of the difference and duration of the instants at which the gyroscopic reaction is insufficient are just about equal to the magnitude of the difference and duration of the instants at which it is in excess of what is required.

It will be gathered from this discussion that the Sperry system does not aim at achieving complete stabilisation—that is to say, at obtaining at each and every instant an exact balance between the vertical component of the gyroscopic reaction and the heeling moment, which a fully stabilised ship has to withstand from the waves. The exact degree by which it falls short of this criterion of perfection depends in any given ship fitted with a given size of stabiliser upon the wave conditions. The extent to which the vessel will roll, depending as it does on the lack of perfection in the balancing of the moments applied by the waves and the gyroscope, must also vary with the wave conditions. As a general indication, it may be said that a vessel rolling with her stabiliser out of action up to about 40 deg. out to out, would be expected with the stabiliser at work to roll on the average to not more than about 3 deg.

The Sperry stabilising system has now been fitted to a large number of vessels, mostly of the pleasure yacht class. An installation of particular interest is that supplied for the Japanese aircraft carrier "Hosho," a vessel of about 10,000 tons displacement at full load. This ship has a metacentric height of 3·35ft., and a period of roll of 12 sec. The gyroscopic equipment consists of a fly-wheel of forged steel 12ft. 6in. in diameter, weighing 62 tons and running at 815 r.p.m. The moment of inertia of the wheel is 2,834,000 in pounds and feet, and the centrifugal stress in its rim is about 13½ tons per square inch. A turbo-generator of 185 kVA capacity supplies the alternating current used for driving the fly-wheel.

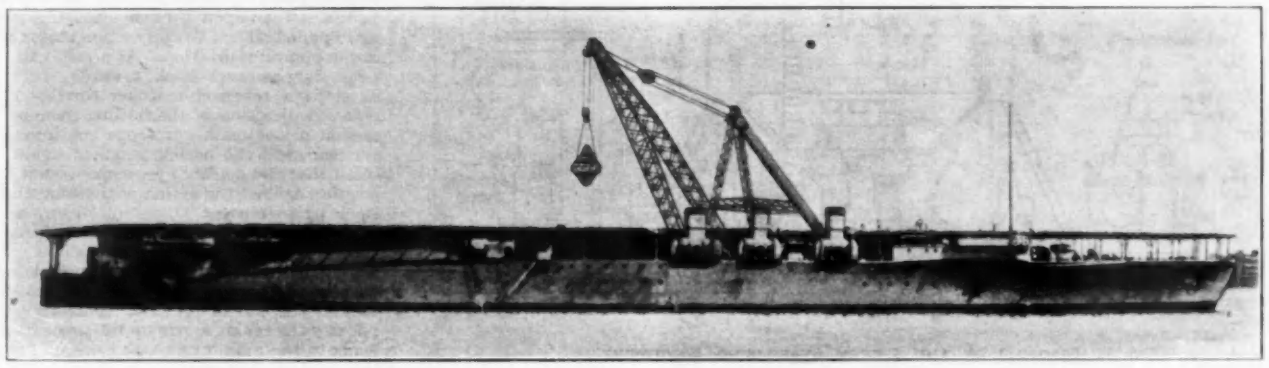


FIG. 37—JAPANESE AIRCRAFT CARRIER "HOSHO" AND HER STABILISING EQUIPMENT

The direct current for the precession motor is supplied by a generator of 110 kW capacity. In Fig. 37 we reproduce a photograph which serves to illustrate the relative size of the "Hosho" and her stabiliser. The total weight of the stabilising equipment, including the electrical gear, is about 200 tons, or 2 per cent. of the vessel's displacement. This particular equipment has been in service for about six years, and is stated to have given complete satisfaction. It is on record that when unstabilised vessels similar to the "Hosho" were rolling through a total amplitude of 40 deg., the stabilised aircraft carrier showed simultaneously a maximum total amplitude of 2 deg. to 2½ deg.

(To be continued.)

The Development and Progress of the Aero Engine.*

By H. R. RICARDO, F.R.S.

THE possibility of sustained flight by heavier-than-air machines was fully recognised during the last century by those who had studied the aerodynamic problems involved, and it was realised that its accomplishment awaited only the development of a prime mover of sufficiently light weight.

Of all the known forms of prime mover, the internal combustion engine alone held out any promise of fulfilling the conditions necessary for sustained flight, namely, light weight, not only of the engine itself, but also of the fuel it consumes. Early attempts had, however, been made to fly with steam propulsion, and it is of interest to note that the very remarkable and cleverly designed steam plant employed by Sir Hiram Maxim in 1894 was actually very considerably lighter per horse-power, even including the boiler and condenser, than the petrol engine used successfully some nine years later by the Wright brothers. Although, in the last century, short flights would have been possible with the aid of the steam engine, yet with so hungry and thirsty a creature, prolonged flight was quite out of the question, on the grounds of catering alone.

The rapid progress of the internal combustion engine during the last fifty years has been one of the most remarkable developments of mechanical engineering. Fifty years ago, its minimum weight was about 500 lb. per horse-power, and its use in consequence was restricted solely to stationary purposes. Forty years ago it had dropped to about 75 lb. per horse-power, and its use for road transport began to develop. Thirty years ago its maximum weight had dropped to about 10 lb. per horse-power—by this time it had already begun to revolutionise road transport and the victory of the air was close at hand. Twenty years ago its weight could be reduced to 3 lb. per horse-power, and flight had become an accomplished fact. Since that date the minimum weight had dropped further to a little over 1½ lb. per horse-power, and in the case of racing engines to well below 1 lb.

The achievement of flight made its deepest impression in France, and it was France alone who, during the first few years after the Wright brothers' success, grasped the immense future of aviation and at once devoted her best talent to the development of suitable engines. Of these early developments, the most brilliant, the most original, and the most daring example was the 50 H.P. Gnome engine designed by Monsieur Seguin. This remarkable engine, which was actually in use as early as 1907, weighed less than 3 lb. per horse-power. It was quickly followed by a larger version in which the weight was further reduced to but little over 2 lb. per horse-power, and this, in turn, was followed by the Gnome Monosoupape engine, an even more daring design by the same author. In the Gnome

* The Royal Aeronautical Society, eighteenth Wilbur Wright Memorial Lecture, Friday, May 30th, 1930.

engine we have an example of a complete departure from all past experience and tradition, such as has seldom occurred in any engineering development. Of other engines designed and produced in France solely and specifically for aircraft during these early days, one may cite such examples as Le Rhone, Clerget, Canton-Unné, Renault, Anzani, and many others, to indicate the great confidence which France and the French manufacturers placed in the future of aviation. During the same period, we, in England made only very half-hearted and sporadic attempts to produce an engine suitable for aircraft. Doubts as to the commercial future and the belief ingrained in all English engineers that after oak, cast iron was the bulwark of Great Britain, combined to hinder development in this country. It was not, in fact, until half-way through the Great War that we were able finally to break with the cast iron habit and to abandon a material which had served our forefathers so well for lamp-posts and kitchen ranges. During the war, the aero-engine underwent a period of intensive development to which was devoted all the best talent of the countries concerned together with unlimited resources of every kind. We, in this country, entered the war with only one engine with any considerable flying experience to its credit, namely, the much-abused, but very serviceable R.A.F. engine, and we were forced, at the start, to rely almost entirely on our ally, France, for the supply of designs and experience, but it is satisfactory to record that before the end of the war the position had been reversed, and that English-designed and English-built engines were in the ascendancy.

Since the war progress has been steady. For the last ten years it has taken the form of improving and consolidating existing design, and there have been few startling developments. During this period the power output of a given size of engine has been increased by an average of about 40 per cent., thanks, in part, to improved knowledge of the thermodynamic and other problems involved, in part to progress in metallurgy, and to the use of more suitable fuels, but mainly to meticulously careful design, and the daily application of an ever-widening experience in service. The power-weight ratio has not, however, fallen to the same extent, because demands in other directions, such as smoothness of running, a longer working life and refinement generally have in every case caused the same engine to put on flesh as the years roll by. To-day, the modern aero engine is not only about the most efficient prime mover in existence, but it is also one of the most reliable.

If we review the progress of engineering in the past we find that each new line of development starts, of course, with a period of experiment and groping, during which a wide range of types is evolved. By a process of elimination this range is very soon whittled to one or two survivors; in the final choice of these survivors, chance plays often quite as important a part as merit. On the one or more survivors the attention of the whole engineering world is concentrated, with the result that step by step it is improved out of all recognition, and reigns supreme until it reaches almost the very limit of its capacity, when a new and fundamentally better type eventually replaces it. Such has been the history of the steam engine which fifty years ago had crystallised into an almost standard design of open-type, double-acting, slow-running engine. For many years this held undisputed sway until it was displaced by the enclosed high-speed vertical type. This, again, was perfected until it seemed almost final, only to be superseded in turn by the turbine. That this process is so prolonged and that the obsolete so long outlives its days is due to the fact that in every age the new-comer, in its raw and undeveloped state, is invariably pitted against the champion of the older school and challenged to defeat it in the first round. Allowance is seldom made for the fact that the reigning type has enjoyed the benefit of many years' experience under every conceivable condition, supplemented by the combined skill of the best talent in the country, while the new-comer, of course, lacks these advantages. Particularly does this apply to the question of reliability, for reliability is attained only by prolonged experience both in manufacture and in service, none of which are available to the new-comer. It is this attitude of mind, this want of imagination, perhaps, which frequently delays progress and allows obsolete types to outlive their day, and it is an attitude which is particularly prevalent in this country.

Since the war the trend of aero engine design has settled down to two highly developed types of poppet valve petrol engines, the air cooled radial and the V type, water-cooled engine, both of which have approached the extreme limit of their capabilities—what further scope is left for increase of power, reduction of weight, or improvement in economy can now be of a small order only, and, by analogy from the past, it would seem that the time is almost ripe for some innovation more radical than mere detail improvement. The power weight ratio curve of the four leading British engines during the last ten years has already almost flattened out. Power weight ratio of the engine alone is not, of course, by any means the sole criterion; fuel economy is to-day of equal and in many cases even greater importance, but here also the curve appears to have flattened out. The average test-bed consumption figure of the engines, submitted to the Army and Navy competition tests in 1914 was 0·78 lb. per B.H.P. hour, that of the best 0·65 lb. The average consumption of aero engines under similar test conditions in 1922 was about 0·55 lb. and that of the best about 0·48 lb. The average consumption to-day is about 0·52 lb. and of the best examples about 0·46 lb. It may be argued that the performance of the Rolls-Royce and Napier engines which performed so magnificently in the last two Schneider Trophy races belies what I have just said; but it will, I think, be admitted that the superb performance of these engines was attained not so much by improvements which could be incorporated in the normal type, but rather by the use of expedients rendered possible by the conditions of the race, chief of which was the use of specially prepared fuel, and by encroachments on the margin of safety. It must be remembered that the same skill and the same experience is available to the standard Napier and Rolls-Royce engines as to the winners of the Schneider Trophy, yet that skill and experience has not evoked any very startling improvement in the standard engines produced by the same makers. In other words, the remarkable vigour of racing engines is produced by stimulants rather than physique.

We have seen that during the past twelve years the average power output of aero engines of given cylinder capacity has increased by about 40 per cent., and it is worth while to try and analyse the progressive steps by which this improvement has been attained. In the first place there has been an all-round increase of nearly 20 per cent. in the mean effective pressure—this has been attained in part by detail improvements in valve design and operation; in part by the use of a higher compression ratio rendered possible by improvements in the fuel, and in part by improved knowledge of combustion chamber design. There has been an all-round increase in the rotational speed of rather over 20 per cent., brought about by improvements in materials, in mechanical design and in the technique of manufacture, and lastly, there has been an improvement of well over 100 per cent. in the life of the engine between overhauls brought about by extensive experience and meticulous attention to detail. Every increment of power has added both to the dynamic and to the heat stresses and has had step by step to be met by improvements in cooling, in lubrication, in material and in structural stiffness. Each step has revealed the presence of some weak link in the mechanism, and a halt has had to be called till that link could be strengthened. Thus the process has continued, for ever halting to overhaul the chain until ultimately every link will be of equal strength and the limit of the type will be attained. At one step the valve mechanism sets a limit to our speed; next it is the connecting-rod big-end bearing which is overloaded; at the next step the exhaust valve is overheated, or it may be the sparking plug; next detonation intrudes, and so, little by little, fighting every obstacle as it arises, the existing types of aero engines are improved until to-day they represent the very summit of engineering skill.

The improvement in engine performance during the past ten years is due, in no small measure, to the improvement which has been effected in the quality of the fuel, in particular as regards its tendency to detonate. Less than twenty years ago, practically nothing was known about the behaviour of different hydro-carbon fuels; petrol was just any volatile petroleum distillate and was defined by its specific gravity and nothing else. Detonation, which we now take so seriously, and which sets a limit to the ratio of compression we can use, was unknown as such, and was regarded as a form of pre-ignition; this, in turn, was regarded as an evil, for which the engine designer was solely to blame through inadequate cooling.

That the phenomenon of detonation and pre-ignition could be confused was not altogether surprising, for both reacted similarly to the same treatment, that is, better cooling, but when a few years before the war benzole was introduced and detonation disappeared while pre-ignition remained, it became apparent that the two phenomena were quite distinct and that one at least was affected by the fuel. Once this had been observed, the Shell Company instigated a very thorough investigation both into the cause and phenomena of detonation and into the individual behaviour of the various petroleum products. This research was necessarily postponed until after the war, but it very soon revealed that detonation was a phenomenon totally different from pre-ignition and one which depended primarily upon the chemical composition of the fuel.

Petrol, as such, consists of a mixture of hydro-carbons of three series, aromatics, naphthenes and paraffins in varying proportions, depending on the locality of the oil wells. Of these, the former, of which the best known members are benzole and toluene, are the least prone to detonate, while the paraffins are the worst offenders. It was found that by increasing the proportion of aromatics—by suitable blending—detonation could be reduced enormously and much higher ratios of compression could be used with a corresponding gain in power output and efficiency.

Looking back over the last twelve years, we find that the general improvement in the fuels resulting from better knowledge of the behaviour of their several constituents has accounted for an all-round increase in power output and economy of from 10 to 15 per cent., due to the higher ratios of compression which can now be used. Of the 40 per cent. increase in power gained during the last ten years from 10 to 15 per cent. is due, therefore, to the general all-round improvement in the fuels available.

It so happens that the aromatic series of hydro-carbons have a high specific gravity, and since the merit of petrol was formally judged by gravity alone, fuels rich in aromatics were considered as inferior petrols. So strong was this belief that for several years the whole of the output of petrol from the vast oilfields of Borneo was piped out into the forest and burnt; thus, thousands upon thousands of tons of the very finest petrol in the world were wantonly destroyed.

Recently it has been discovered that certain metals, such as lead, thallium and others, suppress detonation when administered even in minute doses, due, it is believed, to their avidity for oxygen, which induces them to rob the unstable peroxides which are present as an intermediate product of combustion and whose instability is the primary cause of detonation.

Clearly we cannot in practice introduce metal in a sufficiently finely divided form into the cylinder of an engine and a suitable compound must be found which is soluble in petrol and which will break down, by dissociation, after its entry to the cylinder. We have also to face the difficulty of getting rid of the metallic oxide left over after combustion. Of the suitable metallic compounds lead tetra ethyl is the best known; this fulfils the required conditions both as regards solubility in petrol and as regards dissociation at an appropriate temperature, while the residual oxide can, to some extent, be carried away by the addition of ethylene dibromide, but to some extent only—with the use of this mixture there is still some residual deposit left, and this is liable to break down the insulation of the sparking plug; hence the use of these anti-detonating metallic dopes is limited to very small doses or to special occasions only.

Air *v.* Water Cooling.

Since flight first started controversy has raged as to the relative merits of air *versus* water-cooled engines, and to-day we are no nearer settlement. In England and in America a slight preference is shown for the air-cooled engine; in France, Germany and Italy there is a slight preference for the water-cooled engine. The advantages of the air-cooled engine are so obvious as, at first sight, to appear almost overwhelming. (1) It is far less vulnerable; (2) it is lighter; in actual fact the dry weight of both air and water-cooled engines is exactly the same; hence the water-cooled engine is the heavier to the extent of the water and radiator it must carry; (3) it is completely immune from all "plumbing" troubles to which the water-cooled engine is very susceptible; (4) it cannot be damaged by frost.

The disadvantages attached to air cooling are:—(1) As yet only one successful type of air-cooled engine of large power has been produced, namely, the radial type. As the power output of this type increases so also does its already considerable frontal area, and the advantage gained in the way of reduced weight is more than offset by increased head resistance. This does not apply to the water-cooled engine to anything like the same extent. (2) In any internal combustion engine the intensity of heat flow is greatest at certain localised points, such as the immediate surroundings of the exhaust valves and sparking plug. In the water-cooled engine heat can be transferred from any local point at an almost limitless rate, but in the air-cooled engine this is not the case, with the result that to avoid local overheating the air-cooled engine has to expend far more energy on cooling itself, in order to scoop the heat out of a few odd recesses; even so, the air-cooled engine is forced to work at a lower efficiency and with more lavish lubrication.

From the time when flight first started till the present day the scales have failed to show any decided tilt towards air or water cooling. It is, perhaps, significant that air-cooled engines predominate in those countries where frost is of frequent occurrence, and water-cooled engines elsewhere, thus indicating that, in practice, the least important of the advantages is sufficient to tilt the scale. While the more extensive use of high-conductivity aluminium cylinder heads tends to widen the scope of air-cooled engines, the use of steam cooling, and perhaps also the use of liquids of higher boiling and lower freezing points, such as ethylene glycol, give a corresponding leg-up to the water-cooled engine. Steam cooling in particular appears most attractive in that it is far less vulnerable, while not only can the surface of the radiator or condenser be reduced, but it can be placed anywhere and made in any convenient and streamline form; thus the leading edge of the wings may be utilised as the condenser surface. The only real advantage I can see in favour of the use of ethylene glycol lies in its low freezing point, for little or nothing is to be gained from its higher boiling point, seeing that the boiling point of water is quite as high a temperature as is wholesome; for any higher temperature results merely in loss of power and an increased tendency to heat troubles, such as gummed-up piston rings, &c.

It is perhaps worth while to consider what scope is left for improvement of aero engines of the present generally accepted types. The power output of any engine is a product of the weight of air it can consume in unit time and of the efficiency with which it can be utilised. With engines of conventional type we can increase the efficiency only by the use of higher ratios of compression, but in this direction we are limited in part by the fuel and in part by the fact that as we increase the compression ratio the gain in efficiency diminishes, while the increase in maximum pressure rises alarmingly. We are nearing the point at which the increase in maximum pressure will necessitate so much additional weight to and involve so much more friction in the moving parts as to neutralise the gain in power and economy.

We can increase the weight of air taken into the cylinder by (1) using oversize cylinders and working them at full capacity at high altitudes only; (2) increasing the speed and so filling the same cylinder more frequently; or (3) by supercharging and so overfilling the cylinder.

The use of oversize and under-filled cylinders has never proved very successful in practice, because it is the dynamic loading rather than the gas pressure which, at the reasonably low pressures used in petrol engines, decides their scantlings and dimensions, with the result that the oversize cylinders are liable to involve an oversize engine generally and the advantage is lost.

The second alternative, namely, increase in speed, involves a large increase in the dynamic forces which vary as the square of the speed. This, in turn, can be met by the use of smaller cylinders in larger numbers, and the trend of development is certainly in this direction, but is limited by the necessity for duplicate ignition systems, which become increasingly heavy and complex as the number of cylinders is increased; the same objection applies also to carburation and distribution.

Supercharging.

The third alternative, namely, supercharging, offers at present much the widest scope for power increase since the weight of air dealt with can be supplemented to any extent without increasing the dynamic forces; but, unfortunately, only at the cost of a very large increase in the heat stresses, some loss of fuel economy and a great increase in the tendency to detonate.

In the poppet valve engine of to-day the exhaust valve is the weakest link in the chain, and it is the strain on this link in particular which is accentuated so enormously by supercharging.

As yet and apart from racing engines, no one has, by supercharging, succeeded in increasing the ground level power of aero engines using ordinary aviation fuels by more than about 10 per cent., the limit being set by the intrusion of detonation and pre-ignition arising from the overheated exhaust valve and plug points. In the case of racing engines, very special fuel mixtures can be prepared which will resist detonation, and thus allow of the combination of supercharging and a high compression ratio, and so greatly relieve the distress of the exhaust valve. Although the presence of the exhaust valve forbids at present the use of any substantial increase by supercharging on the ground, this, of course, does not apply at high altitudes, where the supercharger may be used to restore ground level pressure in the cylinder, and it is in this direction of maintainin ground level power at altitude rather than an all-round increase in power that supercharging is employed, and to this it must probably be restricted so long as the exhaust valve is with us.

Three general systems of supercharging have been tried:

(1) The exhaust driven centrifugal blower;

(2) The gear driven centrifugal blower ; and
(3) The positive displacement type blower.

Of these the exhaust driven blower was developed actively, both during and just after the war. It appears at first sight to be the most attractive, since the waste energy in the exhaust gases can be utilised. In practice, however, it has proved very disappointing. In the first place, the efficiency of the turbo blower is too low, with the result that the loss due to back pressure on the exhaust is equal to, if not greater than, that of driving the blower by gearing, while the festoons of red hot exhaust pipes add to the head resistance of the machine and increase greatly the fire risk.

The exhaust driven fan has now been superseded by the gear driven type, with which ground level density can, if required, be maintained up to an altitude of over 12,000ft., while in very extreme cases, such as that of the Rolls-Royce Schneider Trophy racer, a pressure as high as 14 lb. per square inch above atmosphere has been maintained in the induction pipe, but this was assisted by the forward speed of the machine which, coaxed by a suitable orifice, contributed about 3 lb. per square inch.

In America, the displacement type blower has been used, experimentally at all events, with considerable success. This type would appear to have some decided advantages. In the first place, it runs at a relatively low speed ; hence the gearing problem is greatly simplified. Its efficiency is at all times very slightly greater than that of the centrifugal type, and it is capable of a higher pressure if and when required. Lastly, the power absorbed by the blower when not in service, or when operating at low pressure, is considerably less. The design and manufacture, however, of a displacement type blower involve some very difficult mechanical problems, necessitating the use of very small clearances in a piece of mechanism of large dimensions, liable to distortion and subjected to considerable changes of temperature.

Apart from its use in augmenting the power output, the supercharger plays a valuable part in assisting carburation and distribution. In a multi-cylinder engine the number of carburetters can be reduced and the induction pipe work simplified very considerably.

Sleeve Valve Engines.

Throughout the whole life history of the four-cycle internal combustion engine the exhaust valve has always been the weakest link in the chain. This valve is called upon to operate under exceptionally severe conditions both as regards temperature and mechanical stresses, and in recent years it is almost true to say that the power output of the petrol engine has increased year by year by just the extent to which the metallurgist has improved the material of this critical member. The metallurgist is now probably near the end of his tether, and, in any event, the working temperature of the exhaust valve head has now attained so high a level as to promote appreciable surface combustion during the suction and compression strokes of the engine, thus not only wasting a small proportion of the fuel, but, what is far more serious, raising the whole cycle temperature and thereby increasing the tendency to detonate. If to cool the exhaust valve we increase the ratio of expansion, we at once increase the tendency of a normal fuel to detonate. If we reduce the ratio, we increase the temperature of the exhaust. Thus, a vicious circle is set up from which there seems no escape so long as we tolerate within the combustion chamber a member whose surface is considerable and whose temperature is far above the self-ignition temperature of the fuel. If, therefore, we are to look forward to any substantial increase in performance or to the application of supercharging for purposes other than altitude compensation, we must first abolish the exhaust valve. In the light of present knowledge the only practicable alternative would appear to be the single sleeve valve. This mechanism has also other advantages. In the first place, it is controlled mechanically throughout its whole movement instead of in part mechanically and in part spring-operated, as in the case of the poppet valve. Moreover, since its velocity is almost uniform there are no appreciable acceleration forces for the mechanism to contend with. Hence, so far as the valve gear is concerned, the engine speed may be almost unlimited. The absence of any hot surface in the combustion chamber allows of a much higher ratio of compression, ratio being used actually about one whole ratio higher or conversely it permits the use of inferior fuels.

Lastly, since the engine breathes through gills rather than nostrils, neither the shape nor the cooling of the head need be cumbered by the organs of respiration.

As I have mentioned previously, our best hope of reducing weight lies in the application of supercharging, not only as an altitude correction, but to give an all-round increase in power. The exhaust valve, however, forbids any large increase in ground level horse-power, except when, as in the case of last year's Schneider Trophy races, a very special fuel is employed. With the single sleeve valve engine there is no such limitation and an experimental single sleeve engine has been run heavily supercharged for several hundred hours on ordinary aviation spirit at a break mean pressure of over 400 lb. per square inch, and at a specific output nearly three times greater than that of any aero engine now in service, and that without the least sign of distress or overheating of the sleeve valve. With a fuel comparable with that used in the Schneider Trophy, the same engine will maintain a brake mean pressure of 550 lb. per square inch, when the specific output is almost double that of last year's Schneider Trophy winner. With high degrees of supercharge, the energy available in the exhaust becomes so large as once again to bring into prominence the vexed question of compounding. In the case I have just cited, the exhaust is discharged from the cylinder at a pressure of well over 300 lb. per square inch, and, as such, is capable of doing again almost as much work in a low-pressure cylinder as it has done already in the high-pressure. In the case of the poppet-valve engine, compounding is not worth the candle, because the exhaust valve cannot in any event be made to operate under such severe conditions, while the mechanical and other problems connected with the design of a suitable transfer valve from the high to the low-pressure cylinder appear to be almost insuperable. With the sleeve valve, however, compounding becomes comparatively easy, because the same valve can be arranged to operate both as the inlet and exhaust valve to the high pressure and as the inlet valve to the low-pressure cylinder. By compounding in this manner it should be possible, not only considerably to improve the economy, but also to reduce weight, since the cylinders, which alone have high pressure and temperature to deal with, can be made quite small, while the low-pressure cylinder can be made very light. In a supercharged compound engine one would aim to do the bulk of the work in the two-cycle low-pressure cylinder and to use a pair of quite small high-pressure four-cycle cylinders both to take the bite off the pressure and temperature and to serve as valve gear for the low pressure.

I have enlarged on the question of the single sleeve valve because its use would appear to open up new possibilities unattainable with the poppet valve engine. In the case of water-cooled engines it would seem that the sleeve valve could be substituted for the poppet valve without any material difficulty or additional weight.

In the case of air-cooled engines, however, the problem of cooling the hollow cylinder head of a sleeve valve engine is likely to prove difficult, and very little experience is as yet available.

It has been shown experimentally that the sleeve valve engine is capable of a far greater power output than is attainable from any design of poppet valve engine yet in sight, but I would like again to emphasise that while th high-duty sleeve valve engine is a possible newcomer, it must not be expected in its relatively undeveloped condition at once to outstrip the poppet valve engines of the present day.

In the Army and Navy Competition of 1914 a single sleeve valve engine was entered and put up a very good performance ; it failed through the breakage of its crank shaft, but its performance in every other respect called forth a warm tribute from the judges in their report.

Compression Ignition.

During the last few years aero-engine designers in every country have been turning their attention to the compression ignition or heavy-oil engine. The principal arguments in favour of this engine are :—

(1) The elimination, or at all events the enormous reduction, in the fire risk ;
(2) Much better fuel economy ;
(3) The elimination of electric ignition and thus of interference with wireless communication ;
(4) The use of a cheaper fuel.

These are all weighty arguments and sufficient to justify the large amount of thought and research which is now being lavished over the problem.

The heavy-oil engine was evolved and developed by the last generation as a slow-running engine for heavy industrial work, and its secrets had been so jealously guarded by the last generation and so enshrouded in mystery that for many years none dared tear aside the veil and reveal it as it is—a very commonplace type of heat engine. For twenty years its high priests have assured us that it would work only at a leisurely gait and that it was sheer impudence even to suggest a high-speed version. A few mischievous spirits had made timid attempts to hustle it, but it was not until nine years ago that the Royal Aircraft Establishment stepped boldly in and showed that, treated rough, it could step quite as lively as any other heat engine. To the Royal Aircraft Establishment is due the credit of having first shown the world that the high-speed heavy-oil engine was not only a practical possibility, but that it could actually be made more efficient than its clumsy prototype. The pioneer work by the R.A.E. was soon followed up by other experimenters until to-day almost every aero-engine builder throughout the world is experimenting with the heavy-oil aero engine, and in almost every case he is finding the problem far less difficult than he had expected. In two quite recent papers I have discussed fairly fully the question of combustion in heavy-oil engines, and will not attempt now to do more than summarise the conclusions. In the high-speed compression ignition engine with what is termed solid injection, combustion appears to take place in three distinct phases. First, a delay period, during which fuel is admitted to the cylinder, but either fails to ignite or burns only from one or more minute nuclei ; secondly, a period of rapid pressure rise, during which the fuel which has already been injected burns rapidly at a rate determined by the degree of turbulence within the cylinder ; this continues until the pressure and temperature have reached so high a figure that the remainder of the fuel can burn as it issues from the injector. During the first two phases the pressure rise is largely out of direct mechanical control, but during the last phase it is controlled entirely by the rate of injection from the fuel pump. The smaller the cylinder, or the higher the speed, the longer the delay period ; hence more fuel is burnt under the condition of phase two and the maximum pressure is higher. Thus, while a 5¼in. cylinder working at 1500 r.p.m. will give a certain performance at a maximum pressure of 750 lb. per square inch, to get the same performance at 2400 r.p.m. we have to let the maximum pressure rise to about 850 lb. per square inch. Again, if we reduce from 5¼in. to,say, 4in., we shall have to let the maximum pressure rise by nearly 100 lb. per square inch to obtain the same performance.

In order to obtain the necessary rapid and complete combustion, it is essential that the relative motion between the droplets of liquid fuel and the air within the combustion chamber shall be extremely rapid. Such rapid relative motion can be attained either by shooting the fuel through the air at a very high velocity or by making the air within the cylinder rush past the entering stream of fuel. The former method involves very high injection pressures, very small orifices and accurate aiming of the several fuel jets; the latter method obviates these difficulties and allows of low-pressure injection through a single-hole orifice of relatively large dimensions. It has the advantage also that it is almost completely immune from mechanical obstruction or disturbance. In order, however, to acquire the necessary rapid and orderly rotational flow of the air it is essential to admit it tangentially to the cylinder and as near the circumference as possible ; in other words, through ports in the cylinder wall. This can be accomplished easily enough by the sleeve valve, or by the ports in a two-cycle engine, but it is by no means easy to achieve the same result wtih poppet valves. It would seem, therefore, that the sleeve renders possible a very simple, light and reliable form of heavy-oil engine. On account of the lower mean pressure and also of the unfavourable ratio of mean to maximum pressure the four-cycle heavy-oil engine must, of necessity, be considerably heavier than a petrol engine of similar design. From careful analysis of the various factors it would appear that, given equal skill in design and manufacture, the heavy-oil engine will be some 50 per cent. heavier than a petrol engine of the same power output and of similar general design. The compression ignition engine is, however, admirably fitted to work on the two-stroke cycle, and there seems no fundamental reason why a two-cycle heavy-oil engine should not be developed whose weight would approach very nearly that of a contemporary petrol engine of the same output. With regard to fuel consumption and range, the best petrol engines of to-day show a fuel consumption on the test bed of about 0·46 lb. per square inch, while the best experimental light heavy-oil engines show 0·35 lb. per B.H.P. hour ; this, however, is by no means a fair basis of comparison, for while the petrol engine may with advantage and in flight invariably does consume fully 20 per cent. of excess fuel, the compression ignition engine maintains always its maximum efficiency and, in fact, cannot do otherwise. We ought therefore to compare a petrol engine with a consumption of 0·55 lb. with a heavy-oil engine consumption of 0·35 lb., a difference of 0·2 lb. per B.H.P. hour in favour of the latter. If we take the weights of the fully equipped engines as 2 lb. and 3 lb. per horse-power respectively, we find that the heavy-oil engine will begin to score when the range exceeds five hours. Just recently the Packard Company of America has produced successfully a small radial air-cooled heavy-oil engine of quite exceptionally ingenious mechanical design, the weight of which is said to be little over 2½ lb. per horse-power—a very fine achievement. To accomplish this, however, the reduction gear usually fitted to so high speed an engine has been omitted and it would also appear that the margin of safety has been encroached upon considerably. There is little doubt but that a petrol engine of similar design and with the same margin of safety would weigh less than 1½ lb. per horse-power.

While, on the one hand, it may not be long before heavy-oil engines will take the air in considerable numbers, yet I cannot see that they will oust the petrol engine ; rather, I think, each will find its own sphere of usefulness for many years to come.

The intensive research which has been carried out during the last few years on heavy-oil engines has, naturally, thrown fresh light on certain of the problems connected with petrol engines, particularly as regards fuel distribution to the several cylinders. The petrol engine of to-day uses a carburetter and from it distributes a mixture of partially vaporised fuel and air to the various cylinders. In the event of any cylinder receiving a weak and slow-burning mixture flame lingers in the combustion chamber throughout the exhaust stroke, with the result that on the opening of the inlet valve the whole mixture in the induction pipe is ignited, and what is known as a backfire occurs. This is always alarming to the pilot and sometimes even dangerous. To avoid risk of backfire or of losing his engine when opening up after idling, the pilot invariably works with a somewhat rich mixture which is very wasteful in fuel.

The system of distributing a partially vaporised mixture to a bank of cylinders has been in vogue since the petrol engine first appeared, and though its evils are recognised, they have come to be accepted as inevitable. The alternative system of injecting into each cylinder an accurately measured quantity of liquid fuel has generally been considered as altogether too difficult even to attempt. In the case of the heavy-oil engine, however, this problem has had to be solved and has, in fact, presented far less difficulty than anyone would have dared to predict. Some thirteen years ago the late Major Norman carried out some very promising experiments along these lines, and but for his untimely death they would probably have been brought to a successful issue. Some five years ago, and after a good deal of experience with injection problems in heavy-oil engines, a long series of experiments on similar lines were again put in hand, when it was found that both a higher power output and cooler running could be obtained when the fuel was injected during the suction stroke, since the whole of the latent heat of evaporation of the fuel was available within the cylinder both to cool the latter and to lower the temperature and so increase the density of the entering air. It was found, as would be expected, that weaker mixtures could be used with, of course, complete immunity from any risk of backfiring. Experiment also showed that with the sleeve valve engine advantage could be taken to secure some measure of stratification and so realise a still further economy. Yet further experiment revealed that when the fuel was finely pulverised by injection under higher pressure, safety fuels of high flash point could be utilised. Fuel consumption as low as 0·41 lb. per horse power and brake mean pressure as high as 150 lb. per square inch could by such means be obtained in a relatively low compression petrol engine without any increase of weight at all. Quite recently Hesselman has produced an engine in which the fuel is injected under high pressure towards the end of the compression stroke and immediately before ignition ; by such means he is able to use still heavier fuels, but since the fuel is injected after the inlet valve is closed, the latent heat of evaporation is no longer available for increasing the air charge, and the power output is, in consequence, reduced considerably.

I have endeavoured to outline some of the directions in which a departure from orthodox practice might usefully be considered ; further than that I will not attempt. The prophet of old had an easy time. He was free to predict whatever came into his head, but was generally able to ensure that only his good shots were remembered. The prophet of to-day has no such easy task, for all his predictions are recorded. In the race for the best aero engine I am prepared to suggest some of the possible runners, but I will not attempt to spot the winner.

A HIGH-PRESSURE 8in. gas main, 6520ft. long, has been laid across the Hudson River in America in just over eleven days. The joints in the pipe were made by butt welding with a 3ft. sleeve of 9in. pipe also welded in place at each end.

The Kitson-Still Locomotive.

ON April 24th Colonel E. Kitson Clark, chairman of Kitson and Co., past-President, presented a paper before the Institution of Locomotive Engineers, dealing with the latest developments of the Kitson-Still locomotives resulting from runs of considerable importance made in the North of England. Some of the principal points in the paper are summarised below.

The Boiler and Burner.—The steam side was dealt with first. The boiler was required to produce 8000 lb. of steam per hour, and assuming an evaporation of 11 lb. per lb. of oil, the rate of combustion required was 17 lb. of oil per cubic foot of fire-box volume. In order that no part of the latter should be wasted, the flame was made to spread quickly, and the combustion to start early, thus filling the space completely.

Having supplied a suitable flame, the concomitant requisite was, as always, air, and consequently, also as always, special attention had to be directed to the vacuum in the smoke-box and the position and size of the blast-pipe nozzle. Nine types of blast-pipes were tried and these in their turn were varied with at least three permutations and combinations of chimney diameter and petticoat size and length.

At the fire-box end louvre plates were introduced behind the burner to provide masking, constriction and direction to the entering air. The final result was a combination that gave efficiency of combustion with quietness. The combination also assured that if there were black smoke there would be an objectionable throbbing, so that the operator who is insensitive to the iniquity of smoke would be persuaded by the unpleasantness of the throbbing to correct his error of adjustment.

Reversing Gear.—There is a special interest in the reversing gear in view of the dual control of steam and internal combustion. Both reversing gears—Fig. 1—are screw gears. Their hand wheels are concentric. The larger wheel controls the internal combustion, the smaller the steam side. Their relations are effected by a "liaison nut" A, that may be traversed on a square on the steam shaft B by rotation of either the square shaft or internally screwed internal combustion hand wheel shank C.

The internal combustion gear may be locked in three positions—forward, central, and backward—by a bolt D, which engages a notch in plates E or F.

The internal combustion action is depicted in the drawing as in central gear, whilst the steam side is in full forward gear.

The steam gear handle is now free to set its gear over the whole range from full forward to full backward. The handle by turning performs its required function as to the valve motion. At the same time it revolves the "liaison nut" A, screwing it along inside the internal combustion handle shank C.

If we now start with the internal combustion in "mid," the steam in "forward" gear, the internal combustion shank can only turn in the sense which screws the "liaison nut" in the direction to which it is free—that is, into forward gear. When the internal combustion gear has reached "forward" position, the nut has reached the centre of its range and further motion is prevented by stops at the valve gear.

The internal combustion and steam are both in forward gear. If in error, the driver then tries to turn the steam gear past "mid" position to backward, he revolves the steam shaft B, and screws the "liaison nut" still further in the track it has begun. But being already in the centre, the nut has only half its full range, and coming to its stop, arrests the steam wheel at half its range—that is, in the "mid" gear position. It can go no further, and the steam cannot be in opposition to the internal combustion.

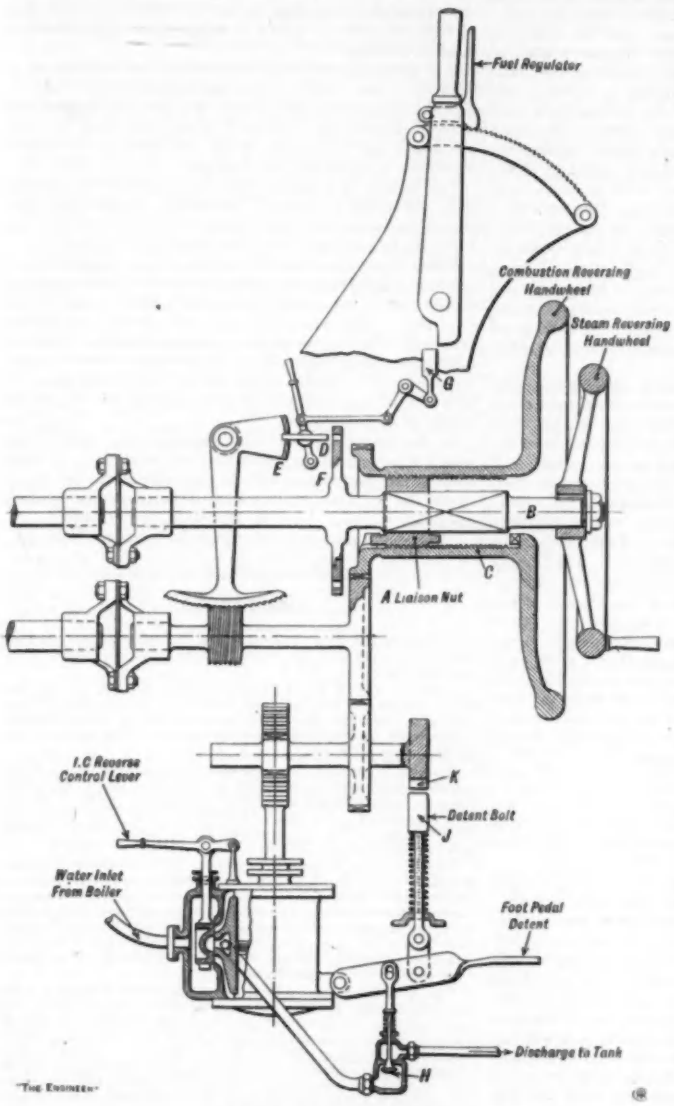


FIG. 1—REVERSING GEAR

Opposite to and facing one another are a disc F and quadrant E, E conforming to the action of the combustion gear, F to that of the steam reversing gear. Between them is a checking bolt D, which prevents the motion of the one if the other is free, and *vice versâ*. This checking bolt has a mastery over the internal combustion oil supply, in that when it frees the internal combustion gear from movement it prevents the regulator being opened, by means of detent G.

Of the two gears, the steam is very easy to run round. The internal combustion requires power. It is obtained from boiler water, this being exhausted to the feed tank. By this means a sufficient head is maintained in the exhausting side of the cylinder to provide a damping action, and so obviate the necessity of the addition of a cataract cylinder.

At the end of the stroke the mechanism is brought gently to rest by a device incorporated in the exhaust pipe to the tank. This, a poppet valve H, through which the exhausting water from the cylinder passes on its way to the tank, is inserted in the pipe. It is connected by links to the detent pin J, and by giving easement of the pin J into a notch K the valve is closed as the pin is pushed in by spring L. Cushioning and final arrest is obtained by this short period of throttling and eventual closing of the exhaust pipe, and the valve also protects a leaky admission valve heating the feed water or allowing the gear to "creep."

The reversal of any internal combustion direct-coupled locomotive presents a problem different from that of other internal combustion machines. The reversing gear coming to the neutral position must provide an anti-compression arrangement for the following reason:—Starting a locomotive requires an application of power at full torque. Therefore, an addition to the load by cylinder compression would create an unjustifiable demand for power. Moreover, the delicate stopping of a locomotive in shunting and marshalling, must be free from checks or pushes that might arise from a stored-up compression. Therefore, mechanism is embodied in this gear so as to hold the inlet valves open when the reversing gear is at "mid" position. This relieves compression in the cylinders when starting or moving under steam only, and reduces the resistance during the first revolutions. One cylinder, however, remains under compression, but this is not an excessive opposition to the action of the engine at starting; it may even be an assistance.

Fuel Injection System.—The airless fuel injection has given a remarkable amount of flexibility. The lowest range for firing is 30 r.p.m.; the highest 500 r.p.m.

There is one injection pump to four cylinders with the necessary distributors incorporated in the pump.

The valve seats have been made of tool steel or cylinder cast iron, and it may be of interest to record the fact that the latter has proved equally satisfactory with the former. The latter has in many cases been thought advisable in order to eliminate the danger of the steel of the valve spindle seizing with the steel sleeve.

The pump cam is driven at twice the engine speed, thus giving two injections per engine revolution. The cylinders operate on the four-stroke cycle. Consequently, one pump can supply four cylinders. The profile of the pump has been simplified down to a pure excentric, with perfectly satisfactory results. Experience of the behaviour of the pump at the extreme variations of speed where full power is required has pointed to the necessity for control of the injection timing. At slow speeds it is necessary to retard the injection and reduce the delivery of the pump. It is clear that without such a gear the pump, at a control position suitable for maximum power, at high speeds, would, at slow speeds, allow an excessive charge of oil to be delivered.

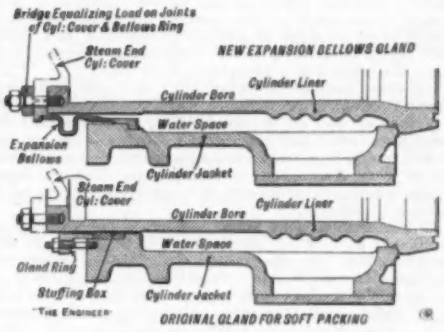


FIG. 2—EXPANSION GLAND

Expansion Gland.—The expansion gland round the cylinder liner in its jacket failed to retain the boiler water, which absorbs the excess heat of combustion reaction. The trouble with these glands has persisted through all the trials, and there has not been an opportunity to apply the solution to the actual locomotive. But the cure prescribed is full and complete.

The problem arises from conditions which were imposed in design, namely, a square cylinder jacket casting attached to an inflexible entablature by bolts on two sides, embracing with a very small interspace a cylinder whose expansion was inexorable, though small. The packing space was an annulus of 15¾in. diameter, no more than $\frac{1}{16}$in. wide and 2¼in. deep.

This space proved too meagre for the satisfactory use of even the most celebrated types of soft packing. The result has been that on nearly every run loss of expensive boiler water has been incurred.

The remedy consists of a steel expansion bellows joining the jacket to the liner—see Fig. 2. It is welded at one end to the jacket and carried at the other by a jointing ring on the end face of the liner. These bellows are formed of steel plate pressed to a form which presents two diaphragms by which movement is accommodated. The diaphragms are normal to the line of movement, and they can therefore deflect slightly without distorting the diameters of the cylindrical portion.

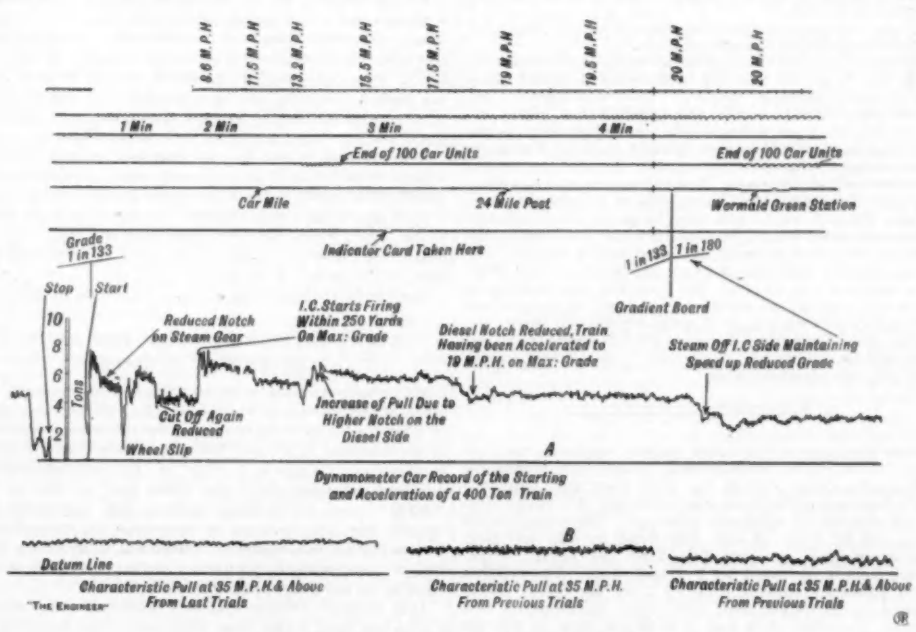


FIG. 3—TYPICAL DYNAMOMETER RECORDS

One of these has been fitted to the experimental unit cylinder at Leeds, and subjected to drastic tests, and has given every satisfaction. Opportunity was taken at the same time to lighten some of the items comprising the combustion valve gear, with the consequence that it has been possible to increase the speed to more than 500 r.p.m., and this with a range of variations of m.e.p. extending from 91 lb. at 50, 100, and 200 revolutions, through 100 lb. at 400 revolutions, to 88 lb. at 505 r.p.m., with considerably lower initial pressure than before the change was made.

On the locomotive troubles occurred owing to the improper position of the suction orifice for the oil pump. Water which found its way into the gear case displaced the oil from the bottom of the sump and intruded into the lubricating system.

Further, the lubricating medium, after performing its work, could not find its way back with sufficient speed to the sump at the bottom of the crank case. A 1¼in. drain pipe was fitted to take away one-quarter of the oil which was supplied from a 1in. pump at 40 lb. pressure. This ample drainage was, however, insufficient and the outer cranks were found to be dipping into the oil with undesirable results, as oil was thereby extruded from the crank case diaphragms and covers.

That this and other improvements were required was a matter that took some little time to find, and it was mentioned as an illustration of the difficulties of locomotive testing. Observations of the behaviour of an engine on rollers is of the greatest value, but this is incomplete without the experience of the road, and experience on the road owing to the variations of the phenomena is an education which absorbs no little time.

All these matters, however, have been put right, with happy results.

Trials of the Locomotive.—After these matters had been discovered and put right, a further series of runs, higher in speed on longer journeys without stopping, were taken from Darlington to Redcar and Barnard Castle. These conditions presented the opportunities for taking indicator diagrams.

Indicator cards were found to be irregular, and it transpired that as both fuel pumps drew oil from the fuel tank by a common pipe, the suction of the one interfered with the other at high speeds. Therefore, a separate pipe was led from the tank to each pump. The fuel pump's automatic valves were loaded by light springs, and, following this change, the injection settings were retarded. These important but somewhat elusive defects being remedied, the result was eminently satisfactory, as is clear by the "previous" and "later" draw pull curves of Fig. 3B.

Subsequently a dynamometer car, followed by trains of goods and passenger stock, was attached to the locomotive, and a route accorded from Darlington to Starbeck. The results of this great privilege are more fully treated than the preceding experiences. The behaviour of the locomotive was known, and an opportunity to show the valuation of its work had now come.

Of the lessons learnt, not the least important is that the overall consumption can be kept down by so driving that the oil engine is at all times working as nearly as possible at its full capacity, whilst the steam is retained as an auxiliary. The method of curing the heavy losses of boiler water recorded above justify the adjustment of the overall consumption so far as concerns the steam partner, and figures taken from the double journey with 420 tons of goods stock—runs 3 and 4—will illustrate both these points: "If there had been only one intermediate stop each way (and no signal checks) on runs 3 and 4, the total of 643 horse-power hours put into the drawbar would have remained approximately the same, but the separate items of power supplied by the steam—including all the steam power actually recorded on the bank and during an exceptionally long period, 12 min., to work the train dead slow into the yard at Starbeck—would have added up 94 drawbar horse-power hours, leaving 549 for the combustion engine to make up the same total. The resulting overall consumption figures then become 0·987 lb. per drawbar horse-power hour, and 19·25 lb. per 1000 train ton-miles, or in round figures 1 lb. of oil per horse-power put into the train, or 20 lb. of 1000 train ton-miles hauled, locomotive excluded."

Of the dynamometer records, a sample is here presented, which is of peculiar interest—Fig. 3A.

A train of 397 tons behind the locomotive was travelling at 30 m.p.h. on the 1 in 133 bank, when a distant signal unexpectedly stood at danger. Power was shut off, the speed dropped to 15 m.p.h., the signal cleared, power was re-applied, the train still against a 1 in 133 gradient, began acceleration, but was finally brought to a dead stop for plate-laying work. This occurred at the steepest part of the track on a severe curve. The subsequent and encouraging story is told by the figure. Steam started the train, raising the pull to 8 tons. For 75 yards the locomotive proceeded under steam, when the internal combustion was put on and fired at once and acceleration began. The steam cut-off was then reduced in stages until "mid" gear position was reached, the 1 in 133 was finished at 20 m.p.h.—speed increasing—and the end of the gradient was carried at 28 m.p.h. on internal combustion alone.

The other trials were one with 450-ton goods train, one with 406-ton passenger stock and a demonstration run with 382-ton passenger stock.

THE Ministry of Transport railway statistics for February, 1930, have recently been issued as a Stationery Office publication, price 3s. 6d. They show that, compared with February, 1929, there was a decrease of 7·05 per cent. in the number of passenger journeys. Passengers at full fares fell by 4·73 per cent., but those by day and half-day excursions increased by 17·63 per cent. Workmen's tickets increased by 3·57 per cent. The receipts from passenger tickets rose by 5·00 per cent., owing mainly to 19·54 per cent. more from excursionists and despite the offset of a loss of 6·43 per cent. in the full fares. The tonnage of goods traffic advanced by 5·15 per cent., and the receipts therefrom by 1·75 per cent. General merchandise itself rose by 4·58 per cent. in tonnage and 2·10 per cent. in receipts. The additional passenger business was earned by an increase of 1·97 per cent. in the passenger train mileage and the improvement in the goods business by 0·69 per cent. more goods train miles.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE UNEMPLOYMENT PROBLEM.

SIR,—Your correspondent, Mr. Tunville Gardner, in your current issue, writing on the unemployment problem, does a great service to students of the subject by showing the state of mind or ideas which prevail rather generally among a large number of engineers. Let us reflect a moment upon who and what we are. Engineers are the practical scientists who have put into operation the ideas which have raised man above the beasts of burden, and done more for civilisation than all the philosophers and preachers the world has produced. Surplus potential labour or unemployment is a passing phase, caused by wholesale mechanical production, thereby releasing thousands of otherwise necessary workers. With our system of economics and finance, we have for ages obtained purchasing power or exchange principally by the results of manual labour. Now that this labour is no longer required, are we to die or be wiped off the face of the earth for want of some other form of purchasing power? Almost all the things of the earth are produced for the benefit of man; therefore, for want of purchasing power, the system of production immediately becomes clogged by what we rather stupidly call over-production.

Thousands are suffering from under-consumption, yet all the warehouses are so full that valuable ships have to be used as store places for the world's vast wealth, and although we have in the world huge supplies of commodities, yet they tell us "the world is over-populated." There may be logic in what so many people so glibly repeat, but I entirely fail to see it. Mr. R. Gaudin, in your issue of March 21st, expressed it beautifully in "unemployment is a sign of progress." I will go further, and say that strikes and discontent come under the same category. The trouble in India, China, and the rest of the world are sure signs of awakening and demanding a share of the things of life other than the proverbial "smell of an oily rag," upon which they are supposed to have been able to exist in the past. One of the best signs of progress that I know of is to see these things being discussed in a paper like THE ENGINEER, which cannot be said to suffer from political bias, the leading articles with which we have been treated lately standing out for clearness of thought far beyond anything we get in ordinary newspapers.

Cardiff, June 2nd. E. F. M.

SIR,—I have just read in THE ENGINEER of April 11th the letter of Mr. J. E. Tuke on the above-mentioned problem.

I cannot agree with his statement "that unemployment is the result of our scientific and industrial development," and that "it is a problem of putting across the product from the factory to the home." I submit that unemployment is the result of faulty economic organisation, that it is a world problem, and that it is insoluble if considered exclusively from a national point of view, no matter how big and powerful the nation or empire may be, which seeks the solution. If sought for its own people alone, it will fail.

It would be trespassing too much on your space, and possibly on the patience of your readers, to go into detailed arguments, but the following remarks may show the drift of what I mean.

In a recent daily paper I read that a "hunger march" to London was being organised, and on the same page is a statement that grave fears were entertained that American wheat would be dumped into England. Is there not food for thought here?

Unemployment, *per se*, is not an enemy. The enemy is the poverty which usually accompanies it. Now, wealth is, of course, the opposite of, and the antidote for, poverty, and wealth is the product of labour, of industry, of employment. The logical deduction would seem to be that with our present industrial development sufficient wealth could be produced to abolish poverty throughout the civilised world and that with relatively little manual labour.

The problem is one for international economists and organisers and has little to do with the "mechanism for distributing goods." On some goods introduced into this market the freight may amount to some 3 or 4 per cent. of the value, whilst the duty, stampage and other charges—all unnecessary—will reach 60 or 80, or even 100 per cent. of the value. *Verb. sap.*

Buenos Aires, May 14th. E. GARRETT.

SOME MATERIALS USED FOR NAVAL ENGINEERING PURPOSES.

SIR,—In your issue of April 18th last an account was given of the discussion which took place at the Institution of Naval Architects on the paper by Engineer-Captain J. Hope Harrison, R.N., on "Some Materials Used for Naval Engineering Purposes." One of the contributors is reported as deprecating the stress laid on the use of "ATV" steel for turbine blading, and expressing the opinion that the amount so used must be insignificant. It was further mentioned that from one source over 1000 tons of stainless steel—probably meaning chromium steel—have so far been supplied for this purpose.

It is, however, evident that very much larger tonnages of 3 to 5 per cent. nickel steel must have been supplied for the same purpose. Yet nobody would pretend that this is a proof of superiority in favour of 5 per cent. nickel steel.

Tonnage figures do not, therefore, tell the whole story, but so far as they are of importance in indicating progress accomplished, the figures for "ATV" are by no means insignificant. In total to date some 750 tons of "ATV" have been employed for the blading of steam turbines of all kinds, to which another 200 tons may be added for other purposes, such as steam valves. Turbines of a total horse-power of more than 1½ millions have so far been equipped, in whole or in part, with blading of this material, omitting that which is being embodied in current construction.

The author of the paper in question is, however, primarily concerned with marine engineering, and although the manufacturer is not always acquainted with the destination of the material he supplies, it can be definitely stated that at least 350 tons of "ATV" blading have been fitted in marine turbines.

It is in connection with marine work that comparison of "ATV" steel with "stainless"—chromium—steel is perhaps most illuminating, since it is well known that the latter suffers rapid corrosion when subjected to contaminated and salt-laden steam, a condition extremely prevalent in the machinery of ships.

The failure of stainless steel to withstand completely such conditions is common knowledge, while after more than seven years of experience one has yet to learn of the necessity to replace "ATV" blading from this cause.

When engineering practice surpassed the capabilities of ordinary blading material it was inevitable that the designer should seek to meet his requirements with the least expensive type of steel which will yield the efficiency he desires. It is only when he has failed to obtain success or obtained incomplete satisfaction in the employment of the cheaper range of non-corrodible steels that he will decide upon the necessity of experimentation with more efficient materials, higher in their first cost.

In the case of turbine blading experimental results take a long time to accrue. It is often two or three years after installation before any definite conclusion can be drawn as to the success or otherwise of a particular blading material. E. HUGH M. NICHOLSON,

Sheffield, June 2nd. Commander, R.N. (Ret'd.).

CONTRACTS.

THE HUNSLET ENGINE COMPANY, Ltd., of Leeds, has received an order from H.E.H. the Nizam's State Railways Board for six boilers for locomotives.

JOHN THOMPSON WATER TUBE BOILERS, Ltd., of London and Wolverhampton, has received from the Metropolitan Water Board an order for the supply and erection of three complete boiler units for Surbiton pumping station. The value of the order is nearly £30,000.

ESCHER WYSS AND CO. S.A., of 20, Grosvenor-gardens, Westminster, S.W. 1, have received an order for two large turbo-blowers, each arranged with individual turbine drive, to operate in conjunction with blast-furnaces of the Tata Iron and Steel Company, Ltd., Jamshedpur, India. Each of these blowers will normally inspire 130,000 cubic feet of air per minute.

THE ENGLISH ELECTRIC COMPANY, Ltd., of Queen's House, Kingsway, London, W.C. 2, has received the following orders:—(*a*) From the Bradford Corporation for twelve double-deck top-covered, three-axle type electric trolley omnibuses, each having a seating capacity for fifty-six passengers; and (*b*) from Balfour, Beatty and Co., Ltd., for the Nottinghamshire and Derbyshire Traction Company, for six single-deck, two-axle type, saloon type electric trolley omnibuses.

THE MITCHELL CONVEYOR AND TRANSPORTER COMPANY, Ltd., Atlantic House, 45–50, Holborn-viaduct, London, E.C. 1, has received from the West Midlands Joint Electricity Authority an order for the coal-handling plant for the new Ironbridge power station. The plant will comprise "Mitchell" side-discharge weighing type tipplers for unloading colliery wagons up to 20 tons capacity, and a series of ball bearing type belt conveyors for placing the coal into the boiler-house bunkers or into store; and a travelling store bridge spanning the coal store fitted with two elevators for reclaiming coal from store.

THE INSTITUTION OF CIVIL ENGINEERS—AWARDS FOR PAPERS.—The Council of the Institution of Civil Engineers has recently made the following awards in respect of papers read and discussed at the ordinary meetings during session 1929–1930:—Telford Gold Medals to Messrs. David Anderson, M. Inst. C.E. (London), and B. B. Haskew, M. Inst. C.E. (Weston-super-Mare); a Watt Gold Medal to Mr. A. E. L. Chorlton, M. Inst. C.E. (London); Telford Premiums to Mr. W. T. Everall, M. Inst. C.E. (Lahore); Professor E. G. Coker, F.R.S., M. Inst. C.E. (London); Messrs. G. L. Groves, M. Inst. C.E. (Croydon); R. C. Bristow, M. Inst. C.E. (Cochin); E. T. Ward, M. Inst. C.E. (Sulina, Roumania); Gerald Lacey, Assoc. M. Inst. C.E. (Bombay); R. W. S. Thompson, Assoc. M. Inst. C.E. (Sheffield); and R. F. Hindmarsh, M. Inst. C.E. (Newcastle-on-Tyne).

ROYAL INSTITUTE OF BRITISH ARCHITECTS—R.I.B.A. MAINTENANCE SCHOLARSHIP IN ARCHITECTURE.—The Royal Institute of British Architects offers for award in July, 1930, one R.I.B.A. Maintenance Scholarship in Architecture of a maximum value of £100 per annum, tenable from October, 1930. The scholarship will be tenable in the first instance for one year and will be renewable for two further periods of one year each. It is intended to enable a student, who has not the necessary means, to attend an approved course at one of the Schools of Architecture recognised for exemption from the R.I.B.A. examinations. Students who are already taking such a course are also eligible to apply for a scholarship. The value of the scholarship, up to the limit of £100, will depend upon the financial circumstances of the parents or guardians of the candidates. Particulars and forms of application may be obtained free on application to the Secretary to the Board of Architectural Education, R.I.B.A., 9, Conduit-street, London, W. 1. The closing date for the receipt of applications is June 30th, 1930.

ENGINEERING GOLFING SOCIETY.—The spring meeting of the Engineering Golfing Society was held at Sunningdale on Thursday, May 29th. In the morning there was a medal round, and in the first division the President's Challenge Cup and Memento were won by J. R. Dallmeyer with 78–6=72, the second prize being taken by R. E. Doewra with 85–7=78, after a tie with P. V. Hunter with 85–7=78. In the second division the Wilson Challenge Cup and Memento were won by H. P. Gaze with 96–18=78, and the second prize by W. E. Lane with 97–16=81 after a tie with E. C. Stevens with 95–14=81. The Captain's prizes for the best scratch scores in both divisions were won as follows:—First division, by J. R. Dallmeyer with 78; second division, by William Phillips with 94. In the afternoon four-ball foursomes were played against bogey, the Timmis Challenge Cups and Mementoes being won by S. Groom and S. E. Page with 7 up, the second prizes being held over on account of a triple tie between H. V. Gaud and H. G. Hale, C. R. D. Pritchett and E. S. New, and G. H. Hopewell and P. V. Hunter, to be played off. The prizes were distributed by the President, Sir R. A. Hadfield. There were fifty-one competitors.

Railway and Road Matters.

THE repainting of Waterloo Station, Southern Railway, now in hand, will require about 12 tons of paint, will occupy many weeks, and is likely to cost nearly £10,000.

THE reconstruction of Leicester-square tube station will be commenced in about two months' time. It is to be on the same lines as, but smaller than, the station at Piccadilly-circus, *e.g.*, with shop showcases in the circulating area. The cost will probably be about £400,000.

WE fail to find, in the list of Birthday Honours, the name of anyone connected with railways. As associated with roads we have to record that Mr. C. H. Bressey, the Chief Engineer of the Roads Department of the Ministry of Transport, is made a Companion of the Bath.

WHILST the motor car drove a lot of first-class passengers from the railway to the road, there are now signs of a reaction, says the London correspondent of the *Manchester Guardian*. The motor, he says, is not far from beginning to suffer from its own success. At any rate, as road travel becomes more overcrowded and difficult many people are becoming converted, or re-converted, to the railway doctrine that for long journeys no better form of travel has been invented than a seat in a first-class railway carriage.

THE financial statement and report of Mr. C. T. Cramp, the general secretary of the National Union of Railwaymen, shows that at the end of 1929 that body had £1,202,098 to its credit, so that it has recovered from the losses incurred during the General Strike and coal stoppage in 1926, in which year it paid away £1,564,266 and brought its finances down to £580,001. We do not, however, see any mention in Mr. Cramp's report—which was reproduced in full in the *Railway Review* of May 23rd—as to the number of members in the union.

THE fatal accident which occurred recently to a substation attendant at Loughborough Junction will, no doubt, be fully investigated and reported upon by the Assistant Inspecting Officers of the Ministry of Transport. The coroner considered that there was a lack of supervision at night time, as the man was alone on duty from 11 p.m. to 7 a.m., without anyone visiting him. That could not, he remarked, be regarded as satisfactory, as, apart from the question of electrical shock from apparatus—which appeared to be adequately safeguarded—there was a possibility of a man receiving an injury or being seized with sudden illness.

A VISIT was paid recently by the Association of Technical and Professional Staff of the London, Midland and Scottish Railway to the Rolls-Royce works at Derby. Members of the Association from the C.M.E., Electric Engineer's, Motive Power, Signal and Telegraph and Road Motor Departments took part in the visit. They came from widely separated centres, and the fact that their chiefs gave them leave of absence may be taken as indicating the confidence of the railway in the good that results from the various departments and centres foregathering from time to time. Obviously the Association enjoys the full sympathy of the President and Vice-Presidents of the company.

A FEATURE of interest at St. Enoch's Station, Glasgow, is the peculiar arrangement adopted for the signalling. The points are operated by means of the usual levers in a locking frame and point rodding, but the signals are actuated electrically by means of slides superimposed on, and interlocked with, the point levers. That arrangement not only greatly reduces the labour of the signalmen, but economises in space, *e.g.*, the 100 levers and slides in Clyde Junction box occupy a length of only 12ft. 8½in. The five frames in the station yard—Station box, 488 levers and slides; Clyde Junction, 100; Gorbals Junction, 68; Saltmarket Junction, 28; and Staff box, 22; a total of 706 levers and slides—now require renewing, and are to be replaced under a contract with the Westinghouse Brake and Saxby Signal Company, by one all-electrically power-operated box, having only 204 levers.

THE Railway Rates Tribunal opened on May 21st its annual review of railway charges ordered by Section 59 of the Railways Act, 1921. Mr. Bruce Thomas, for the railway companies, said that there were three matters which the Court had to determine. The first was whether the deficiency on the working in 1929 was due to lack of efficiency or economy in the management. It was decided a year ago that that was not so, and an examination of the accounts for 1929 would, he thought, lead to a similar conclusion now. They next had to consider whether the deficiency was likely to continue, and on that point the companies could see no evidence of a recovery in trade which might be expected to prevent a continuance of the deficiency. The third point would then be whether the railway charges could be modified to meet the deficiency. The opinion of the companies on that point was that, in view of the present industrial and economic conditions of the country, it was doubtful whether an increase in the charges would result in any material improvement in the financial position of the railways.

THE fatal collision of March 6th at Culgaith has provided a very interesting development. Whilst the Ministry of Transport inquiry left the public in doubt as to the cause of the accident the coroner's inquest definitely proved that the driver—who was killed—started from Culgaith with the signal against him. Subsequently a passenger died from his injuries and at the second inquest the fact came out that it was the fireman who was driving the train, and so it was he, and not the driver, who passed the signal at "danger." As a result the fireman, on the advice of his trade union representative, declined to give evidence. It was stated at the time that the fireman did not give evidence at the inquiry by Colonel Trench because he was away through his injuries, but that officer subsequently resumed and completed his inquiries at the L.M.S. headquarters at Derby on April 12th. The fireman then said that he was driving the train under his driver's instructions. On the subject generally we would observe that it is only by firemen temporarily acting as drivers that they can learn to drive, and we see no objection to that being done under the driver's instructions. That does not, however, relieve the driver of any responsibility. The jury returned an open verdict.

Notes and Memoranda.

IT is claimed that the addition of not more than 0·1 per cent. of selenium to lead increases its resistance to corrosion by sulphuric acid.

IN the case of steel contining more than about 0·5 per cent. of copper its hardness is, according to Messrs. H. Buchholtz and W. Köster, increased by tempering at about 500 deg. Cent.

IN the spring of last year an old building in Wall-street, New York, was vacated. A month later it was completely demolished. In thirty-three weeks a seventy-one storey skyscraper had been completed in its place.

IT is claimed that the Standard Mascot No. 1 Well in the Midway Field of the San Joaquim Valley, California, is the deepest hole in the world. It is 9629ft. deep and took 458 days to drill. The diameter at the bottom is 7¼in.

ACCORDING to the *Chemical Trade Journal*, a Soviet engineer named Gawrilenko has succeeded in working out the factory details for the production of colloidal graphite for use as a boiler feed water additive. A special factory for the production of this material is being erected and should be ready for operation about September 1st next. Its yearly capacity is to be 1500 tons.

IT has been reported that bismuth up to 2 per cent., like silicon, increases the electric resistance of steel without diminution of the magnetic permeability or dissipation of energy through hysteresis. Bismuth steels have been suggested as a substitute for silicon steels for transformer sheet. From a study of the iron-bismuth diagram it is difficult to understand how bismuth steels can be made.

A SIMPLE yet reliable method of distinguishing between hide glue and bone glue is described by Dr. H. Maier-Bode and Dr. O. Gerngross in the *Farben-Zeitung* of May 17th. The solution of glue under test is acidified with dilute sulphuric acid and warmed to about 70 deg. Cent. If the material is bone glue sulphur dioxide is evolved and is recognised by its odour and by its action on litmus paper. With hide glue solutions, however, there is no evolution of sulphur dioxide.

A NOVEL feature of the trial trip on the Clyde of the new White Star liner "Britannic," which took place recently, was the use of Marconi telephone sets fitted on board and in the builders' offices at Belfast to enable the engineers and technical experts at sea and ashore to keep in constant touch. This is the first time that the wireless telephone has been used in connection with a ship's trials, and the installation proved of particular value in exchanging reports of the performance of the new ship. The distance apart of the Clyde and the Belfast shipyards is 150 miles, and on several occasions a few minutes' talk by telephone saved much time and trouble. The wireless telephone sets fitted on the liner and in the offices of Messrs. Harland and Wolff were of the Marconi standard type Y.C. 4, which have a power of 500 watts.

MORE than 200 men are, says the *Chemical Trade Journal*, now engaged in the production and despatch of British road tar at one of the world's largest depôts, situated at Ordnance Wharf, Tunnel-avenue, East Greenwich. At this depôt, which is maintained by the South Metropolitan Gas Company, many thousands of gallons of tar, which have been accumulated during the winter months, are held in reserve. In the eleven tar stills of the company more than 25,000 gallons of high-quality tar are daily produced. For the next three months, in addition to the despatch of tar by rail and motor lorries, specially constructed steamers will be calling regularly at the Thames-side jetties for supplies for continental countries. It is interesting to note that more than 10 per cent. of the employees engaged at the depôt are men of over sixty years of age.

THE great importance of non-metallic mineral products led the Mineral Resources Division of the Mines Branch to investigate the production and use of abrasive materials in Canada. As a result of these investigations the Mines Branch has recently issued a monograph on abrasives by V. L. Eardley-Wilmot. It was found necessary to subdivide the report into four parts, which have been published separately as follows:—Part I., No. 673, Siliceous Abrasives; Part II., No. 675, Corundum, Emery and Diamond; Part III., No. 677, Garnet; and Part IV., No. 699, Artificial Abrasives; totalling in all 383 pages and numerous illustrations and diagrams. Part IV., the final instalment, has just been published and describes in detail the history and manufacture of the artificial abrasives—of which, incidentally, there was in 1929 a record production in Canada of 75,000 tons, valued at over seven million dollars. The manufacture of grinding wheels, sandpaper, steel wool and other abrasives is described in detail, as well as their principal industrial applications. Copies of any of the above four parts may be obtained now upon application to the Director, Mines Branch, Department of Mines, Ottawa, Canada.

VALUABLE navigational assistance given by the Marconi direction finder on a North Sea passage in a dense fog is reported by a London Trinity House pilot, who comments on the relief it was to have such an instrument aboard the ship. The pilot reports that the Commonwealth and Dominion Line steamship "Port Denison," on passage from Middlesbrough to Hamburg, left Tees Bay in a dense fog and set course S. 72 E. direct for Elbe No. 1 lightship at a distance of 320 miles. "After running twenty-two hours," he records, "we got bearing of Borkum Riff which put the ship 13 miles ahead of the patent log. We got two other bearings on Borkum Riff and with the last also a bearing on Nordholz, which made an excellent cross. After about an hour we got a bearing on Norddeich which fitted in well with the others. I consequently altered the course to pass 4 miles north of Nordeney lightship and picked it up exactly where I wanted, the bearings being absolutely accurate. This was the first mark we had seen since the Fairway Buoy in Tees Bay, and after the ship had been going at various speeds, slow, half, stop, &c., and running across the tides, it speaks volumes for the accuracy of the direction finder. I can only say it was a great relief to have such an instrument aboard the ship in the dense fog we had on the passage across."

Miscellanea.

DURING the first six months of 1929 the output of British sulphuric acid was 488,000 tons.

THE Municipal Council of Bulawayo has decided to expend £50,000 on additions to its power plant.

THE 6000th locomotive to be built in the Crewe shops of the L.M.S. Railway was completed on May22nd.

THE production of whale oil during the 1929–30 season amounted to 2,400,000 barrels, valued at £9,500,000.

LARGE-SCALE experiments on the liquefaction of coal are being made in Japan by the Chosen Chiso Hiryo K.K.

AN association of Portland cement manufacturers has been formed in New York, with offices at 11, East 44th Street.

THE latest statistics show that the primary forest products of Canada during 1928 were worth 212,950,799 dollars.

A NATURAL gas well has been "brought in" in the Turner Valley, Alberta, with a flow of 42,840,000 cubic feet of gas a day.

IT is proposed to construct a new railway bridge over the Fraser River, British Columbia, near Lillooet, at a cost of 500,000 dollars.

AN entirely new cement making plant is being supplied to the Green Island company, China, by Vickers-Armstrongs, Ltd.

IN Victoria, it has been decided that the plumber's week is five days long, and that his pay shall be at the rate of 1·12 dollars per hour.

A FACTORY capable of producing 50,000 tons of seamless steel tubes annually is to be put up by Page-Hersey Tubes, Ltd., near Welland, Ontario.

Two large orders for seamless steel tube 24in. diameter, in 30ft. lengths, for gas pipe lines, have been received by the National Tube Company, of Pittsburgh.

A NEW entrance is to be made into the Swansea Docks of the Great Western Railway Company, to the west of the present entrance, at a cost of some £1,000,000.

THE first contract in connection with the construction of the new steel works at Pretoria has been arranged. It involves the expenditure of £60,000 on the preparation of the site.

ARRANGEMENTS are being made for the exploitation of a large deposit of asphalt at Kafairé, near Lattakie, Syria, for roadmaking purposes. The material will be shipped through Aleppo.

Two pipe lines for bringing natural gas from the Texas Panhandle district to Chicago are to be laid by several associated companies. The lines will be 700 miles long and the pipes will be 24in. in diameter.

THE power-houses of both the N'Kana and the Mufulira copper mines, Northern Rhodesia, are to be equipped with Lopulco boilers and powdered fuel furnaces. In the first case the boilers will be of 40,000 lb. per hour capacity and in the second of 50,000 lb.

THE death of Major Sir Aston Cooper-Key occurred on May 28th, after a long illness. He was for many years Chief Inspector of Explosives at the Home Office and was also a director of Allen-Liversidge, Ltd. He was 69 years old at the time of his death.

A HYDRO-ELECTRIC power plant is being constructed on the Botocan river in the Laguna province of the Philippine Islands. It is to be equipped with three turbines, two of 10,000 kVA and one of 1200 kVA. The head of water available is 470ft. and the cost is estimated at 10,000,000 dollars.

A BRIDGE in commemoration of the 150th anniversary of the foundation of the city of Bangkok is being built across the river Chow Phya by Dorman, Long and Co. It will be 230 m. long with a bascule span of 60 m. for navigation. The width is to be 10 m. of roadway with two footways of 2·5 m. each.

THE President of the Board of Trade has appointed Alderman E. B. Lewis, J.P., President of the National Chamber of Trade, as an additional member of the Committee recently set up under the chairmanship of Lord Chelmsford, to examine the present situation as regards the British Industries Fair.

THE Polish Minister of Public Works has instructed the Polish Power Committee (Polski Komitet Energetyczny) to prepare detailed plans for the electrification of the whole of the territory of the Polish Republic. The Committee has already started on this work with the aid of specialists on the subject of electrification. The supervision and direction of the whole work has been entrusted to Engineer Sokolnicki, Professor at the Lwow (Lemberg) Polytechnical Institution.

A REVISED supplement to the ninth edition of the I.E.E. Regulations for the Electrical Equipment of Buildings has been issued by the Institution of Electrical Engineers. It relates to radio receiving and valve amplifying apparatus connected to the supply mains, and is in substitution for the corresponding supplement issued in June, 1928, which is now withdrawn. Copies can be obtained, free of charge, on application to the Secretary of the Institution of Electrical Engineers, Savoy-place, Victoria Embankment, London, W.C. 2.

EXPERIMENTS are, says the *South African Mining and Engineering Journal*, at present being carried out on the coaling appliance at the Bluff, Durban, by railway harbour engineers to ascertain, if possible, the cause of the present excessive breaking of coal during its passage through the machine. Durban shipping agents have for some time now been receiving complaints from buyers of Natal coal in the East that consignments arrive at their destination in a broken state. It is suggested that the breakage takes place while the coal is passing through the coaling appliance. There are nine stages through which the coal passes before it reaches the ship's hold, and samples are being taken from each stage to ascertain the amount of damage caused by each movement. So far, no results have been published.

THE SHANNON HYDRO-ELECTRIC POWER UNDERTAKING

(*For description see page 638.*)

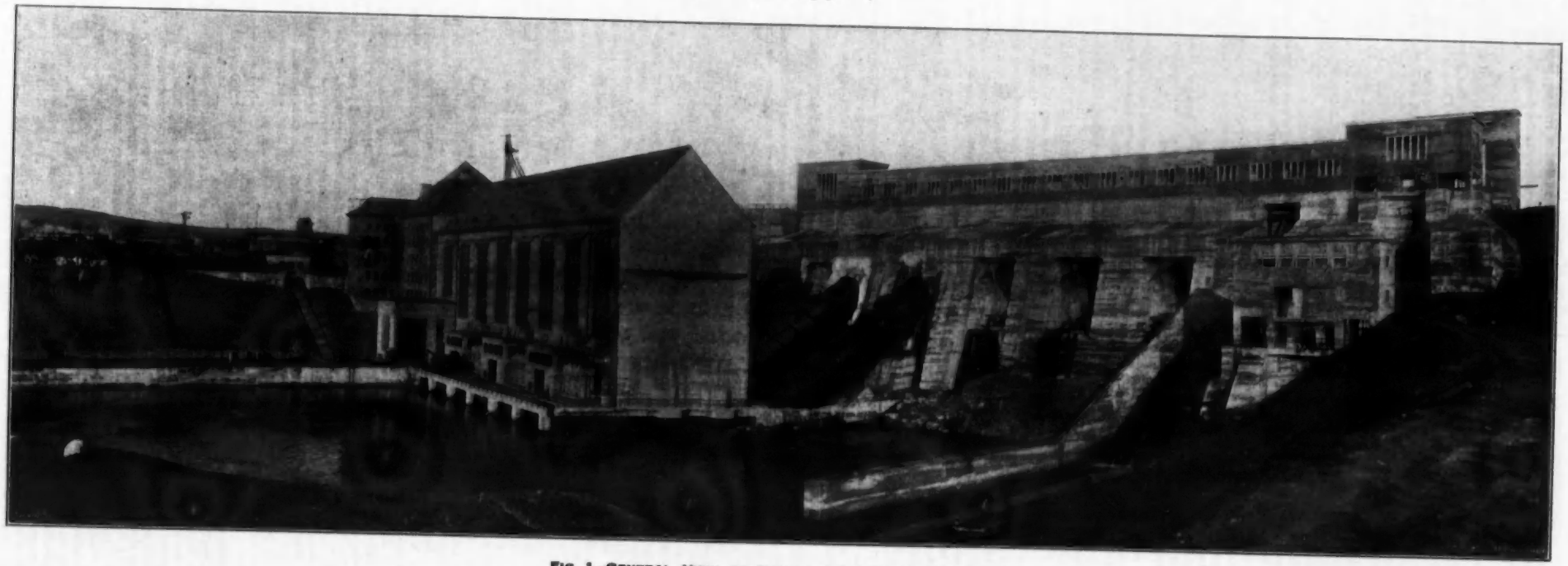


FIG. 1—GENERAL VIEW OF POWER-HOUSE AT ARDNACRUSHA

FIG. 2—INTERIOR OF GENERATOR ROOM

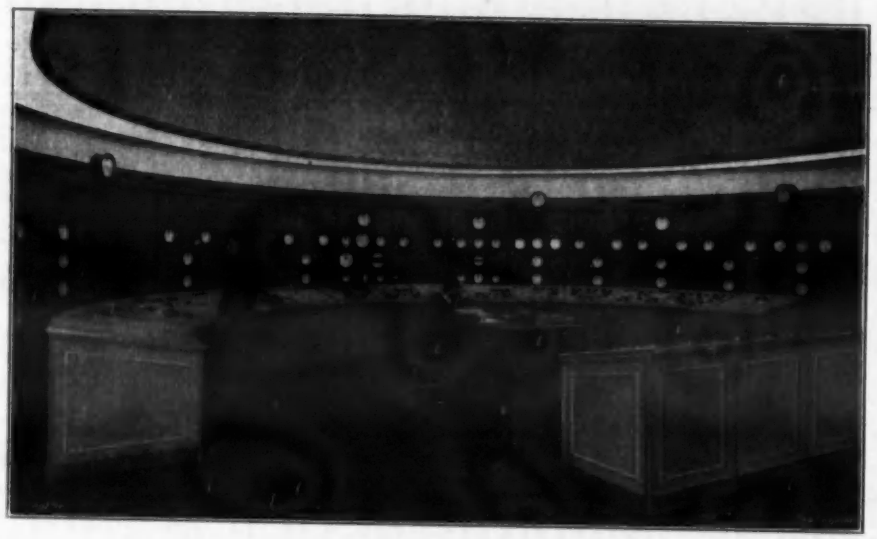


FIG. 3—CONTROL ROOM

The Engineer

Annual Subscription Rates

(including postal charges).

Subscriptions will be accepted by the Publisher direct or through a newsagent at the rates and in the currencies stated below :—

BRITISH ISLES	.. ..	£3	5	0	
CANADA	.. .. ..	£3	3	0	Thick Paper edition.
		£2	18	6	Thin Paper edition.
ABROAD	.. .. ..	£3	7	6	Thick Paper edition.
(except Canada)		£3	3	0	Thin Paper edition.

AFRICA	Central News Agency. All Branches
* £3 7s. 6d.	CAPE TOWN : Wm. Dawson and Sons, Ltd.,
† £3 3s. 0d.	29–31, Long-street (Box 489)
	JOHANNESBURG : C. Juta and Co.
ARGENTINE ..	BUENOS AIRES : Mitchell's Book Store, 576,
* £3 7s. 6d.	Cangallo
† £3 3s. 0d.	
AUSTRALIA ..	Gordon and Gotch (Australasia), Ltd. All
* £3 7s. 6d.	Branches
† £3 3s. 0d.	MELBOURNE : Robertson and Mullens,
	Elizabeth-street
BELGIUM ..	BRUXELLES : W. H. Smith and Son, 78–80,
* Fr. 590	Rue du Marché-aux-Herbes
† Fr. 550	
CANADA	American News Company, Ltd. All Branches
* $15·25	MONTREAL : Gordon and Gotch, Ltd., 334,
† $14·25	Notre Dame-street, W.
	TORONTO : Wm. Dawson and Sons, Ltd., 87,
	Queen-street East
	TORONTO : Gordon and Gotch, Ltd., 81,
	Queen-street West
CEYLON	COLOMBO : Wijayartna and Co.
* Rs. 44·5	
† Rs. 41·5	
CHINA	HONG KONG : Kelly and Walsh, Ltd.
* $37	SHANGHAI : Kelly and Walsh, Ltd.
† $34·5	
EGYPT	CAIRO : Express Book and Stationery Store,
* £3 7s. 6d. (Pt. 330)	9, Chareh Maghrabi
† £3 3s. 0d. (Pt. 308)	
FINLAND ..	HELSINGFORS : Akademiska Bokhandeln;
* M. 650	Alexandersgatan, 7
† M. 605	
FRANCE	PARIS : Boyveau and Chevillet, Rue de la
* Fr. 418	Banque, 22
† Fr. 390	PARIS : Librairie Berger-Leverault, 229, Bld.
	St. Germain
	PARIS : Brentano's, 37, Av. de l'Opera
	PARIS : Dunod, 92, Rue Bonaparte
	PARIS : W. H. Smith and Son, 248, Rue de
	Rivoli
GERMANY ..	BERLIN-LICHTERFELDE-WEST : H. Her-
* R. mks. 70·00	manns, Dahlemer Strasse 64 A
† R. mks. 65·00	WESTERN GERMANY : Fritz Rehfus, Blumen-
	thalstrasse 10, Cologne
	LEIPZIG : K. W. Hiersemann, Konigstrasse 29
HOLLAND ..	ROTTERDAM : Hector's Boekhandel, Noord-
* Fl. 41·00	blaak 59
† Fl 38·00	ROTTERDAM : Techn. Boekhandel, "Plan C,"
	Gelderschestraat 4
INDIA	BOMBAY : Thacker and Co., Ltd.
* Rs. 45	CALCUTTA : Thacker, Spink and Co.
† Rs. 42	
ITALY	MILAN : Ulrico Hoepli
* Lire 300	ROME : Maglioni and Strini, 307, Corso
† Lire 280	ROME : Fratelli Treves, Corso Umberto I, 174
	ROME : Fratelli Bocca
	TURIN : Rosenberg and Sellier, v. Maria
	Vittoria 18, and their Branches at Naples
	and Rome
JAPAN	Maruzen Co. All Branches
* £3 7s. 6d.	
† £3 3s. 0d.	
JAMAICA	KINGSTON : Educational Supply Co.
* £3 7s. 6d.	
† £3 3s. 0d.	
NEW ZEALAND	AUCKLAND : Whitcombe and Tombs, Ltd.
* £3 7s. 6d.	Gordon and Gotch, Ltd. All Branches
† £3 3s. 0d.	NAPIER : J. Wilson Craig and Co.
RUSSIA	LENINGRAD : Mezhdunarodnaya Kniga, Pros-
* £3 7s. 6d.	pect Volodarsky, 53 A
† £3 3s. 0d.	MOSCOW : "Litisdat," Kousnetsky Most, 5-15
STRAITS SETTLEMENTS	—SINGAPORE : Kelly and Walsh-
* $29·25	Ltd.
† $27·25	
SWEDEN	STOCKHOLM : A/B Wennergrens Journal -
* Kr. 61·00	expedition, Stockholm 1
† Kr. 57·00	STOCKHOLM : A/B C. E. Fritzes Kungl.,
	Hofbokhandel, Fredsgatan. 2
SWITZERLAND	BERNE : Joh. William De Groot, Laupenstr. 5
* Fr. 85·20	ZURICH : Rosa Leibowicz, 4, Ankerstr.
† Fr. 79·50	
UNITED STATES	International News Co., 131, Varick-street,
OF AMERICA	New York, N.Y., and all Branches
* $16·40	Entered as second-class matter at the Post Office,
† $15·25	New York, N.Y., December 12th, 1896, under the
	Act of March 3rd, 1879 (Section 397, P.L. & R.)

* *Thick Paper.* † *Thin Paper.*

These rates are liable to alteration if exchange fluctuations require it.

*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER in each calendar month.

ADVERTISEMENTS.

The charge for Classified Advertisements is 1/- per line up to one inch—minimum charge 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Thursday afternoon (the day before publication).

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published annually in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

Postal Address, 28, Essex-street, Strand, London, W.C. 2.
Teleg. Address, "Engineer Newspaper, Estrand, London."
Tel. : Central 6565 (3 Lines.)

By arrangement with Reuter's Engineering Service, The Engineer *contains the latest news from all parts of the world which is likely to be of interest to engineers.*

Contents.

THE ENGINEER, June 6th, 1930.

	PAGE
A SEVEN-DAY JOURNAL	621
POSSIBILITIES OF THE HORIZONTAL OPPOSED-PISTON GEARED MARINE OIL ENGINE. (Illus.)	622
THE AUTOMATIC STABILISATION OF SHIPS. No. X. (Illus.)	625
THE DEVELOPMENT AND PROGRESS OF THE AERO-ENGINE	628
THE KITSON-STILL LOCOMOTIVE. (Illus.)	631
LETTERS TO THE EDITOR—	
The Unemployment Problem	632
Some Materials Used for Naval Engineering Purposes	632
CONTRACTS	632
RAILWAY AND ROAD MATTERS	633
NOTES AND MEMORANDA	633
MISCELLANEA	633
LEADING ARTICLES—	
The Development of the Internal Combustion Engine	635
Technological Civilisation	636
LITERATURE	636
FARADAY CENTENARY CELEBRATIONS, 1931	637
INSTITUTION OF ELECTRICAL ENGINEERS : SUMMER MEETING. No. I. (Illus.)	638
AN IMPROVED SEARCHLIGHT FOR AIR DEFENCE. (Illus.)	638
INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION. No. II.	639
ROCK DRILLING IN COLOMBO HARBOUR. (Illus.)	640
LARGE TRANSFORMERS FOR NEW ZEALAND. (Illus.)	641
THE CORNISH PORT OF PADSTOW	641
SIXTY YEARS AGO	641
THE TURKESTAN-SIBERIA RAILWAY	641
A NEW TYPE OF MARINE EVAPORATOR. (Illus.)	641
THE METAL CRYSTAL	641
THREE-WINDING TRANSFORMERS. (Illus.)	642
CANADIAN ENGINEERING NEWS	642
PROVINCIAL LETTERS—	
The Midlands and Staffordshire—Lancashire	643
Sheffield—North of England	644
Scotland—Wales and Adjoining Counties	645
PERSONAL AND BUSINESS ANNOUNCEMENTS	645
CURRENT PRICES FOR METALS AND FUELS	646
FRENCH ENGINEERING NOTES	647
BRITISH PATENT SPECIFICATIONS. (Illus.)	647
FORTHCOMING ENGAGEMENTS	648

NOTICES TO READERS.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

THE ENGINEER.

VOL. CXLIX No. 3882

JUNE 6, 1930.

The Development of the Internal Combustion Engine.

IN the eighteenth Wilbur Wright memorial lecture, delivered last Friday evening before the Royal Areonautical Society, Mr. H. R. Ricardo characterised the rapid progress of the internal combustion engine as one of the most remarkable developments of mechanical engineering during the past fifty years. Of that progress it is fair to say that the most outstanding phases have been the latest—those associated with the development of the engine for aeronautical purposes. Fifty years ago the internal combustion engine weighed about 500 lb. per horse-power and its use was naturally confined to stationary purposes. Ten years later its weight dropped to 75 lb. and engineers began to study the possibility of employing it for road transport. With the passage of another decade, its weight had fallen to 10 lb. and the revolution of road transport had begun. In 1903, the Wright brothers found it possible to build an engine weighing 7 lb. or 8 lb. per horse-power—there is some doubt about the actual figure—and with it they achieved for the first time power-driven flight. Twenty years ago engines weighing 3 lb. per horse-power were available and flight had become generally practised. Since then the weight has fallen to about 1½ lb. as a good average, and for racing purposes engines weighing no more than ⅞ lb. per horse-power have been produced. The remarkable trend of the curve of specific weight revealed by these figures has been accompanied by no loss of efficiency or trustworthiness. On the contrary, these two essential characteristics have been steadily improved simultaneously with the reduction of weight. Mr. Ricardo, in fact, claims that "the modern aero-engine is not only about the most efficient prime mover in existence, but it is also one of the most reliable." What advance, we may well ask, yet remains to be made?

From the able and lucid analysis of the situation which Mr. Ricardo has given us the fact emerges with much clearness that the internal combustion engine for aeronautical purposes as we know it to-day has reached the limit of its development and that further progress is possible only by departing radically from established practice. The directions in which such departure is possible and probable are clearly indicated by Mr. Ricardo. They point towards supercharging, sleeve valves, compound expansion, and the high-speed, compression-ignition, heavy-oil engine. Some of these developments are already well under weigh, but it is in combination with each other, rather than in their separate application, that Mr. Ricardo foresees the possibility of effecting progress. At various stages the development of the internal combustion engine, and the aero-engine in particular, has been hampered by different factors. For some time past the exhaust valve has presented the chief source of difficulty. That valve has to work under very severe conditions of temperature and mechanical stress, and, as Mr. Ricardo has said, the power output of the petrol engine has been increased in strict keeping with the improvement which the metallurgist has found it possible to make in the material of this critical member. Many of the principal lines of development which might be followed lead of necessity to an increase in the severity of the conditions under which the exhaust valve has to operate. Mr. Ricardo is, perhaps, unduly pessimistic concerning the ability of the metallurgist to advance beyond his present best as regards exhaust valve metal. For the present, at any rate, he considers that the difficulty can best be surmounted by abandoning the poppet type of valve and using a sleeve valve. With the exhaust valve trouble removed, the field for the development of supercharging becomes greatly widened. It need no longer be used solely as a means of keeping up the output of the engine at high altitudes, but can be employed to give an increase of power at ground level. The possibilities which lie open in this direction are indicated by the fact that Mr. Ricardo has constructed a sleeve valve engine, heavily supercharged, and has run it without signs of distress for several hundred hours on ordinary—undoped—aviation spirit at a brake mean effective pressure of over 400 lb. per square inch. With a doped fuel similar to that used in the Schneider Trophy machines of last year, the same engine will maintain a brake mean effective pressure of 550 lb. As the degree of supercharging is increased the higher becomes the pressure at which the exhaust is discharged. In Mr. Ricardo's experimental engine the exhaust pressure is well over 300 lb. per square inch. The desirability of using the exhaust in a low-pressure cylinder is therefore apparent. The ultimate design which Mr. Ricardo foresees is one embracing two high-pressure four-cycle sleeve valve cylinders delivering their exhaust into a two-cycle, low-pressure cylinder. The cylinders would probably be water-cooled and the bulk of the work would be done in the low-pressure cylinder. Sleeve valves, supercharging and compounding, it will be gathered, form a connected chain of possible developments. The compression-ignition heavy-oil engine provides a separate line of advance. Much attention is now being paid to the heavy-oil aero-engine in this country and abroad. We already have Beardmore heavy-oil engines in the R 101 and improved engines of the same general design are, it is known, now being developed by the same makers. Other British aero-engine builders are studying the problems involved, and there is little or no fear that in this important development Great Britain will lag behind other countries, as she did in the early days of the petrol aero-engine. It has been definitely proved that the heavy-oil compression-ignition engine is not, as was at one time believed, essentially a slow-speed prime mover. It is fairly certain, too, that as progress is made it will lose much of the weight which now restricts its application. Already it is reported that an American company has succeeded in making a small radial air-cooled heavy-oil engine weighing just a little over 2¼ lb. per horse-power. It is not necessary that the weight of this class of engine should be reduced to that of a petrol engine before it can become competitive. If we allow the heavy-oil engine 50 per cent. extra weight its superior economy in weight of fuel consumed makes it competitive with the petrol engine for flights exceeding five hours in duration. Mr. Ricardo foresees as a development of the near future a heavy-oil, high-speed, light-weight, compression-ignition engine fitted with sleeve valves and running on a two-stroke cycle. He does not, however, believe that engines of this class will oust the petrol engine, but rather that the two types will for many years to come each have its own sphere of usefulness.

It is gratifying to have these assurances that development of the internal combustion engine is not approaching a limit, from one who by universal agreement is notably able to foresee the lines

along which progress is possible and practicable. We may, however, well ask ourselves precisely what new powers such progress will place in our hands, and having obtained them to what ends we shall apply them. Mr. Ricardo directs his efforts to the development and improvement of the internal combustion engine. It would be good to have the guidance of some one equally expert in the designing of aircraft as regards the prospective value of the improvements which Mr. Ricardo has indicated. Some doubt, naturally, assails us as to whether the progress of aviation will be affected to any considerable extent by reducing the weight or increasing the efficiency of aero-engines to the restricted degree which present figures leave open to us. We might, with great labour and expense, halve the specific weight and halve the fuel consumption. Would the increased paying load and the decreased running expenses accruing from these reductions be sufficient to convert civil aviation into a profitable business and free it from the incubus of subsidisation? Alternatively, are we to seek for the advantages of the developments indicated by Mr. Ricardo in the field of military aeronautics? We prefer to believe that the real value of these developments will be found to lie at least as much outside as within civil or military aviation. It is impossible to believe that the internal combustion engine can be developed for one specialised purpose without benefiting all other uses to which that form of prime mover is now applied. Therein we see the chief interest of the remarkably interesting possibilities unfolded to us by Mr. Ricardo.

Technological Civilisation.

LAST year there was published in America a book called *Whither Mankind?* It was a symposium of philosophical articles from various pens, ably edited by Mr. Charles A. Beard. Each of the sixteen authors who contributed to its pages showed from his own standpoint the changes that are taking place in society under the all-pervading influence of modern civilisation. It may justly be described as an optimistic work, for, whilst the writers admitted that the new factors did affect life in some ways which are at first sight not desirable, yet they held that, looked at as a whole the world is better by reason of the development and advances that have taken place in the last two centuries. Even in the Arts the effect, according to Mr. Lewis Mumford, is good. Referring to typography, textiles, furniture, architecture, and city planning, he observes "that science and technics, while they have altered the basis of these arts, have not done away with the possibilities of their proper growth and development." In an Epilogue, Mr. Beard sums up the case as presented in the symposium. One passage from his conclusion may be quoted. "Yet, while the collective note in this volume is strong it would be a mistake to conclude that the individual under the machine is being reduced from a former high estate as an independent thinker and free creator to the level of a cog. Indeed, most of our authors are inclined to doubt whether the altitude of his estate ever was as lofty as generally represented, and they agree that, notwithstanding the collective invasions, his capacity for liberty and the enjoyment of it are, on the whole, greater, not less, than in the feudal age. What appears to be an 'invasion' is, in fact, often merely the recognition of a standard established by science and its application as a means of comfort, convenience, and safety for the community at large."

We have before now noted the apparent anomaly that whilst America is held by some to be the most materialistic nation the world has seen since the destruction of Babylon, yet it is concerning itself with the philosophy of life and living more than any other country at the present time. The interest aroused by *Whither Mankind?* testifies to this fact. Possibly the reason of the book's popularity is to be found in the justification which it gives to the technological progress which is taking place in the United States and possibly that is the reason, too, why "a group of prominent engineers in New York," inspired the preparation of a companion volume entitled *Toward Civilisation*. Engineers were not invited to the first symposium, at which the guests were "specialists in the humanities—law, economics, and ethics." But the engineer feels that his views upon the human aspects of his "revolutionary activities" ought to be heard and the new volume, which has just appeared under the same editor, is the result. It also contains sixteen separate essays, many of them written by engineers, and all of them dealing with the effects which the engineer is producing upon civilisation, and his own reactions towards those effects. The general trend of the discussion may best be shown by an excerpt from the able summary written by Mr. Beard. It runs thus: "Quite rightly, our authors ascribe many of these evils to the unpreparedness of the people for a technical revolution so vast and so varied in its potentialities. But this insistence on a division of responsibility is not followed by an evasion of issues, nor a retreat to discarded modes of dogmatic thought. Indeed, one note runs through all the chapters: the revolution wrought by science and machinery is not completed; it has just started and its immense possibilities are only beginning to be appreciated; hence, a free and easy condemnation out of hand by critics who know nothing of its inner processes and potentialities is bound to be at best superficial. Besides showing that the new drama of mankind has just opened, our authors demonstrate that the spirit of engineering is rationality, a faith in the power of the scientific method to undo what should never have been done, and to realise whatever human imagination may suggest in the way of material and social arrangements." Taking this passage, and it may be safely so taken, as a true reflection of the spirit of the symposium, we see that the scientific and technical world of America is convinced that technological civilisation, if we may so call it, has potentialities for the improvement of the spiritual—there is no other word—improvement of the human race as great as those of the older forms of civilisation which are the constant admiration of the *laudator temporis acti*. The suggestion that the complaints now current are due to the fact that technological civilisation has outrun the ability of man to accommodate himself to the new environment, and that in the course of time he will learn how to make the highest and best of it, is intriguing rather than perfectly convincing. Has not the world always lagged mentally behind the progress of science and technology? Is it not always struggling to accommodate itself to new conditions, and are not those conditions always changing before accommodation has become complete? In the history of architecture that process is continually at work. The successive transitional periods exhibit in part the development of new methods of construction and in part the inability of mankind to adopt changes as soon as they become available. He holds to the accustomed partly from fear of change, but no less from a disinclination to arise from the easy-chair of custom. To this very day we may witness the same thing. The artist rebels against buildings of steel and cement; only slowly is he learning that concrete may be an artistic material, and only slowly is he learning how to design effective buildings constructed of the new materials. Just as the ancients imitated in stone what their predecessors had done in wood, so he finds it hard to escape from the temptation to do in cement things that are proper to wrought stone. We suspect that there is no end to this process. If the world could adopt the episcopal advice and for a few years let science and technological progress cease, it is possible that the world would be able to accommodate its mentality to the new conditions, derive the highest social good from them, and rid them of the features to which philosophers take exception. But unless that inconceivable thing can be done, we must be content to face the certainty that technological civilisation will always be a little in advance of spiritual civilisation. Nevertheless, the influence of scientists and technologists upon the affairs of the world must increase and ever more and more must they take part in the control and government of nations.

For the resentment which the works of the engineer produce, the indifference of the engineers themselves to the feelings of the community are responsible. A hundred years ago that indifference was not only tolerated, but encouraged. No one protested against the creation of the Black Country or the begriming of Sheffield as long as "there was business in it." But a new spirit has arisen. A world better educated will not put up with the hideousness and filth of an earlier age. It demands more amenities, a greater recognition of the fact that it has a right to find some joy in life and pleasure in its surroundings. With the lengthening of leisure which must be the inevitable result, and is indeed the aim, of technological progress, this demand for a more pleasant environment will increase. What is bearable under the impulsion of business is intolerable in our hours of ease. It is in this direction that the engineer will find new scope for his abilities and inventiveness. It must be his object to remove every one of the objectionable features of the great things he has given to mankind and to leave nothing but their merits. He has gone far upon that road, but there is much further to go. But if, as this interesting book suggests, engineers are already visualising the time when they will take a greater position as citizens in the control of nations, we may rest in full confidence that with every succeeding year something will be done to diminish the disagreeable concomitants of engineering progress, and to bring to the front only the best aspect of technological civilisation.

Literature.

Outline of Costing. By W. A. SMITH, A.C.W.A. London: Moore's Modern Methods, Ltd. 1930. Price 5s. net.

MOST of the books on costing which have been reviewed from time to time in these pages have been written to suit the requirements of a large undertaking, and many engineers have stigmatised as unwieldy the schemes therein unfolded, and unjustifiable because of the expensive machinery that is necessary if they are to be operated efficiently. In the "Outline of Costing," however, the author has primarily in mind a factory only employing from 25 to 100 operatives, and accordingly does not describe the various mechanical devices which are an integral part of a big organisation.

The subject is approached in the right spirit, for we are told that "a costing system is not in itself a panacea for all evils, but it . . . may be regarded as an X-ray of all the activities incidental to stores and production." We quite agree, and also welcome the statement that "the information given by a costing system is useless if it is just filed away." But we would remind Mr. Smith that to be really useful to the engineer, the cost accountant must co-operate with the management, so that all information can be presented in the manner most likely to be of real service. We should like to have seen this point emphasised.

No words are wasted in this little treatise, but, while we are glad to be spared details of the various methods of remunerating labour, described *ad nauseam* in many of the books purporting to be occupied with costing, we nevertheless feel that this picture of costing as depicted by Mr. Smith is far too sketchy for the requirements of the manufacturer who is considering the advisability of initiating a system of costing in his factory. For example, types of costing systems are dealt with in a page and a-half (Chapter III.), and the reader will find the important subject of process costing brushed aside with a cursory remark that it "is suitable for chemical manufacturing plants, coal mines," and a few other specified products. We are of opinion that a large number of factories might with advantage be run on a system of process costing, and its operation should undoubtedly be explained in every book that handles factory costing.

The installation of a costing system can hardly be treated exhaustively in three pages (Chapter IV.), and the author contents himself with a bare outline. He advocates dividing factories into departments, and keeping the costs separate, but hardly goes far enough, as every shop should be a distinct unit, with periodical returns furnished so that the foreman can see at a glance the incidence of expenditure.

The analysis of Factory Expenses by means of a monthly statement is admittedly essential, but it is suggested that the form illustrated might be supplemented by another which would merely summarise the items over which the workshop has no control, and give in detail those which a foreman can study with a view to economy.

Undoubtedly a comparison between estimated and actual expenditure under the three headings Material, Labour, and Expense, is most valuable, but instead of the form shown on page 54, it would be better to have one so arranged that the estimate is immediately above the actual cost for each item, so that the two may readily be compared.

When dealing with Material (Chapter VIII.), it should hardly be necessary to point out that "one person should be placed in charge of the stores and made responsible for them," but the author is probably justified in emphasising this condition of true costing, and he might have proceeded to state that no one, not even a foreman, should have a right to enter the stores or take away anything except in the approved manner. In considering the cost of material, the author appears to be rather dogmatic when he affirms that "it is clear that the issues must be priced at the cost of the material, even if the market price has changed since the receipt." This may be the ideal, but in some businesses it would not be possible to carry on if this course were adopted, and it has been found better to use the market price, naturally making the necessary adjustments. Having determined the policy, it should be adhered to consistently. The treatment of scrap is an important item, and we agree that wherever possible a produc-

tion order should be credited with the scrap at scrap value.

The problem of oncost, or expense—the term preferred by the author—is carefully considered in Chapter X., but the different methods of carrying these charges to the production centres is not dwelt upon, and it is considered that the modern machine-hour rate might with advantage be discussed.

Reconciliation of the cost accounts with the financial books of a company is a subject which is frequently ignored or passed over with some incorrect statement such as that "the cost accounts are really in themselves the financial accounts." The two are quite distinct, one may be regarded as external; the other—the cost accounts—internal, and required by the factory management rather than the counting-house, and yet they must not appear to give different results, they must be satisfactorily reconciled or interlocked. The means of doing this are well described by Mr. Smith (Chapter XIII.), and deserve careful study.

In the last chapter the value of statistical reports is advanced, and we read that "there is, in fact, no limit to the possibilities of a complete costing system," and instances are given of how these reports may be prepared. Without doubt, the value of reliable costing to a manufacturing undertaking is immense, and some of the sample forms speak for themselves, but there must be complete harmony between all the different branches of the organisation, the management knowing exactly what information is required, and the cost accountant presenting it in such a manner that it may be readily assimilated.

The conciseness of this "Outline of Costing" will commend it to costing students who already have a rudimentary knowledge of the subject, and to whom it will prove most useful, serving to crystallise and extend their conception of the various problems involved, and at the same time suggesting a wide scope for fuller and extended inquiry. The author knows his subject, though perhaps he takes rather too much for granted.

Electro-plating with Chromium, Copper and Nickel. By B. FREEMAN and F. G. HOPPE. London: Sir Isaac Pitman and Sons, Ltd. 21s.

THE advent of chromium plating has necessitated the development of a new techique involving special methods of deposition not previously employed, because unrequired, in the electro-deposition industry. Apart from the special equipment needed in chromium plating owing to the peculiar nature of the electrolyte, chromic acid—which is a virulent oxidising agent and highly corrosive, both to metals and living tissue—the inadequate throwing power of the solution, which has not been markedly improved even after two or three years of intensive research, has proved to be one of the biggest difficulties, and the chromium plater is continually faced with fresh problems with each new article of intricate pattern or shape that he is asked to plate. Undoubtedly, information on the best means of overcoming these difficulties obtained at first hand, such as the authors of the book under review should be in a position to impart, being respectively technical director and superintendent of the National Chromium Corporation of America, is bound to be of value to all interested in practical chromium plating, and this first attempt to collate and spread the available knowledge on chromium is therefore to be welcomed.

The sections on chromium plating and the closely allied subjects of nickel and copper plating with which the chromium plater is necessarily concerned are informative, and besides giving a good account of the present trend of thought in these subjects, deal in an admirable manner with the methods of overcoming throwing-power difficulties, the details of racking and arrangement of the articles—constituting the cathode—being likely to be particularly useful to the practical man. Barely eighty pages are devoted to the actual deposition of these metals, but they cover the most valuable part of the book; the rest of which gives the impression of having been written with the purpose of expanding the material to approach book size, and with the possible exception of the chapter on testing deposits and solutions contains little that is new.

The first three chapters are devoted to the elementary principles of electro-chemistry, and in the space of some thirty-seven pages the authors have ranged from definitions of electrical units to over-voltage. The matter is substantially accurate, although the phraseology is colloquial and rather loose; but it is so compressed that it is likely to confuse rather than enlighten the average non-scientific reader for whom it is presumably intended. In this lightning review of electro-chemical theory we are told that "we regard an electro-plating process as being 100 per cent. efficient when no decomposition takes place at the cathode—or anode—other than the one in which we are interested," and reference is made to metals—and even hydrogen—being "plated out." This is followed by a useful chapter on the Plating Department, describing the considerations involved in the layout of a plating plant. On page 57 it is stated that most nickel solutions are not agitated, and also that many nickel anodes used in America at present contain 95 per cent. or less nickel—two practices which hardly obtain in a modern plant.

Before reaching the part of the volume which is its *raison d'être* there are two chapters on the polishing and cleaning processes respectively which follow conventional lines. It is somewhat surprising that one short sentence only—page 79—is devoted to the anodic pickling process, a process which is coming increasingly into use prior to nickel plating, resulting, as it does, in perfect adhesion between the nickel deposit and the base metal. In later sections of the book it is stated that the parting of chromium from nickel is never encountered, but that occasionally nickel parts from the base metal. Anodic pickling would put an end to that defect.

In a chapter on specifications for plating the coatings specified are noticeably on the thin side; thus, ·0005in. is stated to be "thick nickel plate on steel previous to chromium plating" (page 86); but opinion in this country inclines to the necessity of a mil—twice this thickness—as the minimum for protection. The following statement also cannot be recommended for practical application:—"When applied directly over brass, the usual thickness of chromium plating is 0·0001in. In view of Baker and Pinner's results, this thickness seems unnecessarily great."

The book should be of value to chemists, engineers and works executives interested in the special technique involved in modern chromium plating, but its high price is likely to put it out of reach of the most likely group of readers—the big army of electro-platers who have recently added chromium plating to their *repertoire* of finishes as a side line. It is attractively produced, in clear type and contains an appendix of general information, an index and a rather limited bibliography, which appears, however, to be practically exclusively concerned with American work, the large amount of important work done in this country and the Continent having been, regrettably, almost entirely ignored.

BOOKS RECEIVED.

The Port of Bombay. Compiled by W. R. S. Sharpe. Bombay: Bombay Port Trust, India.

Jahrbuch der Schiffbautechnischen Gesellschaft. Vol. 32. 1930. Berlin: Julius Springer, Linkstrasse 23, W. 9.

The Barrister. By Sir Harold Morris, K.C. London: Geoffrey Bles, 22, Suffolk-street, W. 1. Price 3s. 6d. net.

Journal of the Royal Agricultural Society of England. Vol. 19. London: John Murray, Albemarle-street, W. Price 15s. net.

The Future of Empire Trade. By J. E. Ray. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, Kingsway, W.C. 2. Price 2s. net.

Proceedings of the Institution of Mechanical Engineers, 1929. Vol. II. London: The Institution of Mechanical Engineers, Storey's-gate, S.W. 1.

Gradients of the London and North-Eastern Railway. By "Voyageur." London: The *Railway Magazine,* 33, Tothill-street, S.W. 1. Price 2s. net.

The Statesman's Year Book, 1930. Edited by M. Epstein, M.A., Ph.D. London: Macmillan and Co., Ltd., St. Martin's-street, W.C. Price 20s. net.

Piping Handbook. By J. H. Walker and Sabin Crocker. London: McGraw-Hill Publishing Company, Ltd., 6, Bouverie-street, E.C. 4. Price 25s. net.

Electrical Distribution Engineering. By H. P. Seelye. London: McGraw-Hill Publishing Company, Ltd., 6, Bouverie-street, E.C. 4. Price 30s. net.

Handbook of Strength Calculations. Air Publication 970. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 3s. net.

Praktische Ergebnisse auf dem Gebiete der Flugasche-Beseitigung und Staubmessung. Berlin: V.D.I.-Verlag G.m.b.H., Dorotheenstrasse 40, N.W. 7. Price 4 marks net.

German-English Dictionary of Technical, Scientific and General Terms. Compiled by A. Webel. London: George Routledge and Sons, Ltd., 68–74, Carter-lane, E.C. 4. Price 36s. net.

Wirtschaftliche Möglichkeiten der Maschinenunterhaltung in landwirtschaftlichen Grossbetrieben. By Dr.-Ing. F. Buschmann. Berlin: V.D.I.-Verlag G.m.b.H., Dorotheenstrasse 40, N.W. 7. Price 3 marks net.

Mineral Resources of the United States, 1926. *Part I.: Metals. Part II.: Non-metals.* By Frank J. Katz. United States: The Superintendent of Documents, Washington, D.C. Price: Vol. I., 1·25 dollars; Vol. II., 1 dollar.

Faraday Centenary Celebrations, 1931.

DATE OF THE CENTENARY.

IN 1831 Michael Faraday, following up the work of Volta, Oersted and Ampère, began, or rather resumed, in his laboratory at the Royal Institution, experiments on the induction of electric currents, and on August 29th, 1831, made the discovery in which lies the origin of the dynamo and starting point of the utilisation of electric power for the purposes of man. On that day, as his Diary shows, he wound two coils of wire on to opposite sides of a soft iron ring, connected one coil to a battery and the other to a galvanometer, and at "make" and "break" of the battery circuit observed deflections of the galvanometer connected in the other circuit From this simple experiment, and the variations of it made by Faraday in succeeding trials, have grown, in the past hundred years, the science of electrical engineering and the great electrical industry in all its phases as we know it to-day. No other experiment in physical science has been more fruitful for mankind. August 29th, 1931, is then the centenary of one of the great events in the history of the world, and the greatest event in the history of electrical engineering.

ORGANISATION OF THE CELEBRATIONS.

It is fitting that the lead should be taken, in the arrangement of the celebrations, by the Royal Institution, for it was to the House of the Institution in Albemarle-street that Faraday came in 1813, a youth of twenty-two, to become assistant to Sir Humphry Davy, who was then the Professor of Chemistry; where later he succeeded Davy, and where he lived and worked and gave his famous lectures throughout his active life. Faraday took up the work begun by Davy, and established in the Institution the tradition of scientific research and exposition of the highest type, which has been followed in it down to the present day.

It is no less fitting that the Royal Institution should have, in the arrangements for 1931, the assistance of the Institution of Electrical Engineers, the body representing in this country the profession and industry which owe their existence to Faraday's greatest discovery. The two institutions have joined forces in making the plans, and they are indebted to a number of other societies and organisations for their courtesy and co-operation. The Royal Society will participate in the celebrations; the British Association for the Advancement of Science has arranged the dates for its centenary meeting in 1931, in London, in consultation with the Joint Committee for the Faraday celebrations; the Federal Council for Chemistry will participate in the arrangement of the Faraday Exhibition, for Faraday's chemical researches, his work on the condensation of gases, his isolation of benzene, and his establishment of the laws of electro-chemistry, are hardly less remarkable than his purely electrical discoveries. Government, university and scientific interests have joined in expressing their interest and offering assistance to make the celebrations worthy of the occasion.

INSTITUTIONS CO-OPERATING IN THE ARRANGEMENTS.

As a first step a conference was called at the Royal Institution on February 5th, 1929, to which a large number of representative institutions were invited. Most of these were represented at the meeting. On April 17th, 1929, a further conference was called at the Institution of Electrical Engineers. These conferences approved the proposals to organise celebrations, and authorised the appointment of committees, one to be called by the Royal Institution and the other by the Institution of Electrical Engineers, to act jointly in the arrangements. Sub-committees, to deal with hospitality and with the Exhibition and publicity, have since been appointed.

PROVISIONAL PROGRAMME AND DATES.

As a result of the work of the committees a scheme for the celebrations has been drawn up and has received the approval of the Managers of the Royal Institution and of the Council of the Institution of Electrical Engineers. The arrangements will include:—

(A) *By the Royal Institution:*

(*a*) Reception of delegates at the Royal Institution. It is intended to invite representative institutions throughout the world to send delegates to the celebrations.

(*b*) A great Faraday commemorative meeting at the Queen's Hall, at which discourses will be given on Faraday's work.

(*c*) Conversazione at the Royal Institution, and other social functions.

(B) *By the Institution of Electrical Engineers:*

(*a*) Electrical conferences of the members of the Institution of Electrical Engineers, and the members of all the other associations connected with the electrical industry.

(*b*) Faraday Exhibition: the central feature of the Faraday Exhibition, which it is proposed to hold in the Albert Hall, and to which the public will be admitted for a period of about ten days, Wednesday, September 23rd, to Saturday, October 3rd, 1931, will be reproductions and illustrations of Faraday's actual experiments, prepared by the Royal Institution, and including a display of some of the historic apparatus. The Institution of Electrical Engineers, the Federal Council for Chemistry, and the representative organisations of the electrical and chemical industries co-operating with them, will illustrate by means of special exhibits the development of electrical and chemical science and industry in all branches which have their origin in Faraday's work. Thus will be illustrated, in a unique display, the fruition of the work of one of the world's greatest natural philosophers.

The Faraday commemorative meeting will be held in the Queen's Hall and will be open to all attending the Faraday celebrations, including those invited by the Royal Institution and those attending the I.E.E. Conference, and the British Association meetings taking place in London at the same time. This would ensure a very large attendance.

The Exhibition will be held in the Albert Hall, which is particularly well suited for the type of exhibition proposed; it will be open to the public from about Wednesday, September 23rd, to Saturday, October 3rd.

The draft programme, with dates, which is still subject to alteration, is as follows:—On Monday, September 21st, there will be a reception of foreign and other delegates at the Royal Institution. In the afternoon and in the evening a Faraday commemorative meeting at the Queen's Hall.

On the Tuesday morning, the summer meeting of the Institution of Electrical Engineers will begin with a joint conference of the Institution and allied associations. The afternoon will be devoted to visits and social events, while in the evening a conversazione will be held by the Royal Institution. The Institution of Electrical Engineers' conversazione will also take place at the Albert Hall, at which the Exhibition will be opened.

On the Wednesday the Institution of Electrical Engineers' meeting and conference will be continued and the Faraday Exhibition will be opened to the public. In the evening the meeting of the British Association will be opened in Westminster Hall.

The Exhibition will be managed by the British Electrical Development Association for, and in the name of, the Institution of Electrical Engineers, and the various associations and organisations connected with the electrical industry are being asked to co-operate by providing the exhibits.

Institution of Electrical Engineers.

SUMMER MEETING.

No. I.

ON Monday last members of the Institution of Electrical Engineers and ladies taking part in the summer meeting left Euston at 8.30 a.m. for Dublin, and in the evening assembled at the Gresham Hotel to meet the Committee of the Irish Centre and to become acquainted with each other. Altogether, there are about 200 participants, the majority of whom are taking part in the complete meeting covering Dublin and Belfast. The Shannon power undertaking, which is now in operation, is, naturally, of considerable interest to electrical engineers, and has, we imagine, been mainly responsible for the Institution's visit to Ireland. Although the capacity of the plant is at present only 90,000 kW, the scheme has involved a great deal of interesting work, most of which has already been dealt with in our columns. In articles appearing in our issues of December 2nd, 9th, 16th, and 23rd of 1927, March 23rd and 30th of 1928, and our issues of April 26th, May 3rd, 10th. 17th, 24th, 31st, and June 7th, 1929, we described the scheme in the course of construction, and little can really be added to what has already been published.

We give on page 634, however, a view of the exterior of the power station as it stands to-day, a view of the interior of the station, and a view of the control room. The station and other parts of the scheme were inspected on Wednesday, March 4th, when the members of the Institution were entertained at luncheon and tea at the Glentworth Hotel, Limerick, as guests of the Electricity Supply Board of the Irish Free State. On the previous day, June 3rd, the members were received in the morning by the Dublin City Commissioners, whilst in the afternoon a motor coach excursion was arranged in county Wicklow in order that the members might inspect the transmission lines. Luncheon and tea were provided at Glendalough, and in the evening there was a reception and dance at the Gresham Hotel. Although we have already discussed the Shannon power scheme at considerable length, it may be said here that in August, 1927, an Electricity Supply Board was established to operate and maintain the entire undertaking. The contract awarded to Siemens-Schuckert included the erection of 110, 38, and 10-kV networks, together with the transforming stations, from which the Board began the erection of low-tension distribution systems in the towns and villages throughout the county.

In the early spring of 1929 over thirty of these new networks were completed and a temporary supply of current was switched on from the Dublin steam station until the Shannon hydro station began to generate in October, 1929. Since then many more new networks have been put into service, and at the present time no fewer than a hundred new networks are being served. The Dublin steam plant, which is being retained as a standby, ceased operating in February of this year, and the whole of the Dublin area is now receiving current from the Shannon station. After prolonged negotiations the Board has at last acquired the Cork station, and the Cork area will also shortly receive its supply from the hydro station at Ardnacrusha. The domestic load in the new areas supplied has reached an average of over 50 per cent. of possible consumers, whilst in some places which were first connected the percentage is 85.

In Dublin and a dozen other of the principal towns sales showrooms have been opened by the Board. A two-part tariff based on a fixed charge of the rateable value plus 1d. per unit for electricity used has been adopted in all new areas as well as in some of the old areas of supply; whilst in Dublin consumers have the option of a 12½ per cent. charge on rateable valuation plus ½d. for current, or a flat rate of 4d. per unit for lighting and 1d. per unit for domestic power. In the Dublin area there is also a water heating rate of ½d. per unit. With a view to increasing the sale of electric power the Board has established a power sales department, and contracts have been entered into with the two largest consumers in the Irish Free State for a supply from the Shannon station, viz., the Ford tractor factory in Cork and the Dublin United Tramways Company, Ltd., the annual consumption of the two concerns together being about 40 million units.

In the new areas of supply the purposes for which power is being used or is about to be used include corn milling, creameries, bakeries, ice making, salt making, water pumping, sewage pumping, lifts, engineering works, laundries, printing works, saw milling, furniture making, stone cutting, silk making, boot and shoe making, shipbuilding, &c.

As we have explained in previous articles, the project for the utilisation of the water power of the Shannon consists of three stages: (*a*) the present "partial development" scheme, under which only Lough Derg is used for storage purposes; (*b*) the "further development," which will take in Lough Allen and Lough Ree for storage; and (*c*) the "final development" scheme, under which the storage of the three lakes will be considerably increased. The cost in round figures for the present partial development scheme is £5,800,000. The three turbines shown in Fig. 2 are of the Francis type and each is rated at 30,000 kVA. Two were made by J. M. Voith and Co. and one by Escher, Wyss and Co.

(To be continued.)

An Improved Searchlight for Air Defence.

By DANIEL BENGTSON, Captain, Royal Swedish Artillery.

A DUTCH firm, the Nederlandsche Apparaten-fabriek Lonneker, has recently perfected a new searchlight of a pattern specially intended for anti-aircraft purposes, coast defence and naval use. Its design is based on the Siemens-Schuckert system. Fig. 1 shows the exterior of a 60in. searchlight. The drum can be elevated from the level up to 180 deg., which means that the beam can be inverted through the zenith. The searchlight commander is therefore able to follow a target even if the aeroplane passes over him. Special gear on the lamp and ventilation arrangements have been fitted to secure steadiness and

FIG. 1—60IN. LONNEKER ANTI-AIRCRAFT SEARCHLIGHT

equality of the light in whatever position the searchlight may be directed. The ventilation device not only exhausts and carries off the hot gases and vapours developed at the arc, but it also screens off the diverging radiation, thus avoiding illumination of the foreground. The lamp is suspended obliquely in the searchlight drum, by which arrangement nearly complete screening is obtained. Fig. 2 is reproduced from an untouched photograph and shows the intensity and concentration of the beam.

The manufacturers bestow great care upon the grinding of glass mirrors, and in the searchlight illustrated no deviation from focus exceeding 1·5 mm. is to be found. The quality of the mirror adds greatly to the total amount of light projected from the searchlight. In high-intensity searchlights, in which the source of light is very small compared with the size of the reflector, and the beam of light projected is consequently very concentrated, it is of the utmost importance that the reflector should be of good quality, for almost infinitesimal faults in it bring about an irregularity in the illumination of the object, which may have an adverse effect upon the observer. The brilliant light and the excellent mirror render the light projection of this searchlight extraordinarily good. It was found to give on the average six times the illumination of the ordinary type of 60in. searchlight.

The success of the apparatus as a whole is, however, more particularly due to the ingenious equipments for laying. That the control is a very important complement to the equipment of a searchlight will be fully realised when regard is had to the fact that, in air defence, an attacking plane should be illumined before it has reached the zone in which the guns can be employed. That requirement means generally that the searchlight should have a considerable range. On the other hand, a searchlight should not be opened when there is little or no probability of finding the enemy with the light after a few seconds' search, for searchlights may betray the defenders' positions.

FIG. 3—CONTROL PILLAR WITH SYNCHRONISED TELESCOPE

Lonneker's searchlight can be controlled from any place at a distance up to 200 yards from the searchlight, a parallax compensation device adjustable for all distances up to 200 yards being built into the control pillar. The control pillar—see Fig. 3—carries a telescope which is preserved parallel with the axis of the searchlight. The parallelism is effected by means of an electric synchronising device, which operates with an error which is negligible relatively to the dispersion angles of the searchlight and telescope.

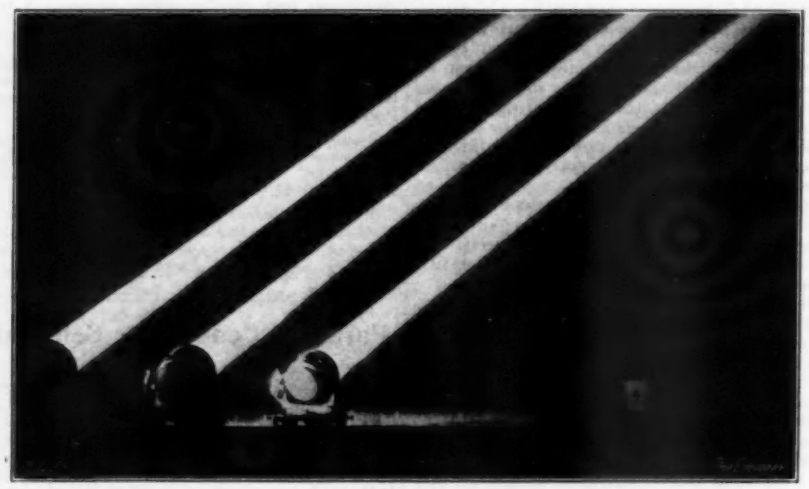


FIG. 2—LONNEKER SEARCHLIGHTS IN ACTION

The searchlight is controlled through a lever built into the control pillar. By turning this lever the motors in the searchlight are supplied with current, and by varying the adjustment of the control lever different speeds in either direction of rotation for both movements can be obtained. Thus the speed may be varied between 60 and 6 seconds for each 90 deg. of rotation. If the control lever is moved simultaneously sideways and upwards the searchlight moves synchronously in both directions and the beam of light follows an inclined path. The turning and elevating

motors of the searchlight transmit motion electrically to the control pillar, so that the telescope may move in constant synchronism with the searchlight. The power is sufficient to prevent the telescope being moved out of step should the observer try, unintentionally or not, to retard it. The advantage of a synchronised telescope lies in the fact that the searchlight commander can extend his search to very wide

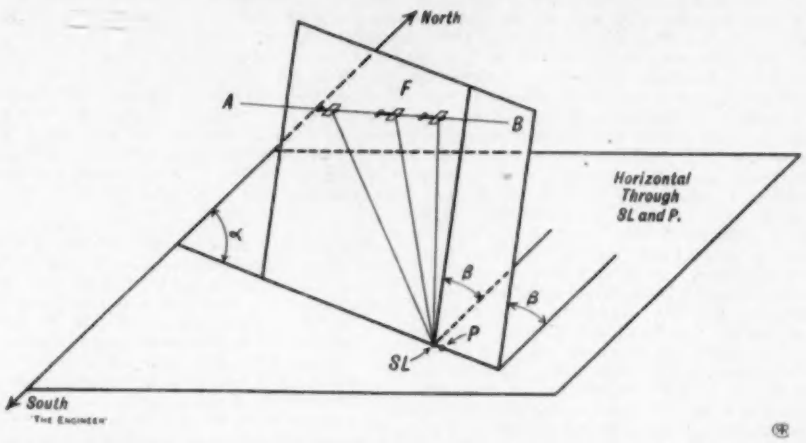


FIG. 4—DIAGRAM ILLUSTRATING METHOD OF MAKING A SEARCH FOR AIRCRAFT

ranges without depending upon a joint action of glasses and light.

It is generally known that searching for a hostile air target is carried out with the help of a sound locator. The most perfect apparatus of this kind cannot do more than indicate the direction from which the sound waves are coming. That direction, however, will not coincide with the true direction of the machine on account of the slow speed of sound. For the correction of the error the distance that the sound has travelled should be known. It is obvious that for the purpose of training a beam of light in the right direction it is inconvenient to employ this distance in the calculations required. The distance is indispensable for the laying of a gun but not for a searchlight.

In order to facilitate successful searching without knowledge of the distance to the target, there is fitted on the control pillar of the Lonneker searchlight an instrument called the planograph. The planograph—see Fig. 5—may be considered as a reconstruction in miniature of the space around the searchlight. In the centre is a pointer indicating the

FIG. 5—PLANOGRAPH ON CONTROL PILLAR

direction of the beam of light. The searchlight, telescope and pointer always keep the same elevation, and the pointer indicates within the planograph the bearing at which the searchlight and the telescope point in space. On the planograph is a semi-circular bow, which can be turned by hand and set as regards elevation and bearing. The pointer just clears the inner edge of the bow. Fig. 4 illustrates diagrammatically the method employed for making a search. The sound locator S L stationed near the searchlight P registers the flight of an approaching machine, and gives the elevation β and bearing α of a fictitious plane F, defined by the searchlight position P and the line of flight A–B.* The purpose of the bow is to visualise this plane in the planograph. The bow is adjusted according to the data obtained from the sound locator. The laying gear of the searchlight is such that a sweeping movement of the beam in the set plane can easily be carried out. By turning the control lever the searchlight can be turned so that the pointer follows the bow. The exactness achieved in a search will depend very much on the quality of the sound locator employed. Should it not be very good, so that deviations due to inaccuracies must be allowed for, the searchlight commander can easily search around the fixed path. For that purpose he can make the pointer swing in "waves," with the edge of the bow as a medium line.

The whole apparatus is constructed to withstand rough usage, and there are no members in the lamp or control mechanism liable to wear quickly. Another important feature is that the motors and the synchronising device in the searchlight can easily be detached for tests, repair, or storage.

* The line of flight is here assumed to be a straight line. It is not always straight, but the speed ahead is many times greater than deviations sideways, and loaded bombers do not change their course or altitude very quickly.

Incorporated Municipal Electrical Association.

No. II. (*Conclusion*).*

OUR notes last week only dealt with the first day's proceedings of the Convention, but the experience of the remaining three days leads to the definite conclusion that from the technical point of view, the Convention has been an unqualified success. In having only one paper per session, the Council acted wisely, and it was happy in the choice of subjects. Indeed, even with this limitation in the number of papers there was, on all occasions, a list of speakers whom it was impossible for the President to call on for lack of time, though it could not fairly be said that any of those who did speak wasted time.

On Wednesday, May 28th, Mr. G. H. Lake, the Borough Electrical Engineer at Derby, read a paper entitled "Pulverised Fuel Firing as affecting Boiler-house Operation," which was frankly written to justify the use of pulverised fuel firing for large power stations. The paper ranks with that presented a few years ago by Mr. T. Roles, Chief Electrical Engineer, at Bradford, in indicating that, at any rate, our larger municipalities are carefully watching the trend of progress, and are quick to follow it. Mr. Roles made it manifest that in the matter of the adoption of high boiler pressures and temperatures, municipalities were playing their part as pioneers, and now in Mr. Lake's case we find the same thing in relation to the use of pulverised fuel. The author himself was the first to congratulate his Electricity Committee on its broadminded attitude, and expressed his appreciation of the very free hand he had been given in carrying out experimental and pioneer work, which, at any rate, some committees might have hesitated about.

The paper gave a brief *résumé* of development in boiler design, but the chief point of interest about it was the operating results that are recorded. The Derby plant has already been described, and its general features are more or less familiar to power station engineers. As the result of his experiences, Mr. Lake sets out the advantages of pulverised fuel firing as follows :—

(1) The removal from the combustion zone of all moving parts which is a logical and progressive development.

(2) Increased operating periods without interruption.

(3) The unquestionable flexibility of the plant, which enables the load demand to be followed accurately.

(4) Greatly decreased coal costs per unit of electricity generated.

(5) Effective control of combustion conditions, irrespective of load on the unit or grade of coal being consumed.

(6) Reduction in overall maintenance of the plant.

(7) Higher daily and annual operating efficiencies.

(8) The increase in evaporative rating.

(9) The reductions in the space occupied yielding valuable savings in capital costs.

(10) The rapidity of raising steam to meet a sudden demand.

(11) A definite advance on the labour conditions associated with operation.

(12) The elimination of all banking losses.

* No. I. appeared May 30th.

The principal problems from the operating point of view had, the author said, been those connected with dust emission and the final ash, and it was well known that many experiments were being carried out to overcome those troubles. With the gas-washing system in use at Derby, it had been found that the early difficulties had been overcome, and once an effective use was found for the final ash deposit, Mr. Lake contended, the whole of the original list of disadvantages would have been overcome.

At Derby the installation had been carried out in three stages, the first two boilers being completed in 1926, the next in 1928, and the last two in 1929–30. Basing the actual capital costs on quotations received for alternative types of plant and buildings, the increased cost of the pulverised fuel plant was some £20,000. During 1928–29, however, the increased number of units distributed in comparison with the previous year was 2,011,000, which at an average price of 1·45d. per unit sold, gave an increased revenue of £12,149 15s., whilst the reduction in the annual coal bill as compared with the previous year was £2326, making a grand total of £14,475 15s. That, the author sumitted, was not only a phenomenal return on the investment represented by the increased capital costs of the plant, but an economic factor of such importance as to establish permanently the claims made for the development.

The author, in his conclusions, claimed that there had unquestionably been an all-round increase of efficiency on the part of pulverised fuel, a result inherent on account of the nearer approach to the theoretical or scientific conditions of combustion. A figure of 10 per cent. was mentioned as the increase in efficiency in boiler-houses in municipal practice during the past three years, and, whilst improvement had also taken place in stoker-fired boiler-houses, it was claimed by Mr. Lake that the whole of this improvement in boiler-house practice was the result of the greater efficiencies associated with pulverised fuel firing or by the challenge which its introduction into boiler-house operation had brought about.

The final balance was assessed as follows. On the debit side we have :—

(1) Certain grades of very hard coal entail high maintenance costs on the preparation plant.

(2) Dust emission from the stacks is still held by many to remain incurable.

(3) Fuel transport costs, particularly fuel of a low-grade character, are often held to rule out the possibilities of their utilisation.

(4) Generally accepted standard boiler designs do not permit of full advantage being obtained from pulverised fuel firing.

(5) The design of the equipment is held by many to be in its early stages of development.

On the credit side, the following merits of pulverised fuel firing were claimed to emerge from the extended experience at Derby :—

(1) From the technical point of view the modern plant is unassailable.

(2) The introduction of water cooling has enabled the designer to take the fullest advantage of the new method of combustion which has led to new and revolutionary practice in steam generation.

(3) From the results of the pioneering experience carried out, it can be claimed that it is now possible to design and construct a boiler plant for any new capital station which takes full advantage of pulverised fuel where the capital costs will be very much lower than with any other form of equipment.

(4) Pulverised fuel equipment has completely emerged from its experimental stages. Thus the importance of all the factors involved are thoroughly appreciated and the means for rational solution along well-defined lines are now available.

The direct results of all this pioneer work indicated, concluded the author, that the design of future plants might closely define the following :—

(*a*) Increased capacities of boilers.

(*b*) Smaller and cheaper buildings.

(*c*) Partial de-sulphurising of gases and dust elimination as a continuous process.

(*d*) Continuous operating efficiencies of 86 per cent.

(*e*) Utilisation of fuels of a cheap character which will keep costs of generation uniformly low.

(*f*) Remote, automatic, and complete control under all conditions of load.

In the long discussion that followed, many views differing from those of the author were expressed, but the whole trend of the discussion was extremely favourable to pulverised fuel firing.

Mr. P. J. Robinson (Chief Electrical Engineer, Liverpool), advocated the possibilities of a combination of pulverised fuel and stoker firing, such as was being adopted at the new Liverpool power station, partly to control the risk of prices for pulverised fuel increasing unduly, and partly to obtain a greater degree of flexibility in operation. Actually, however, certain tests he had carried out, after increasing the

combustion areas on stoker-fired boilers, indicated that there was not much between those and similar-sized pulverised fuel plants in the matter of thermal efficiency. He disagreed with the use of water sprays, as at Derby, for handling the dust, because the water-laden dust that did escape—and there was bound to be some—was distributed over a very small area, and was therefore likely to cause complaints. A number of independent chemists were now investigating this problem at Liverpool, and he believed a scheme had been devised which would get over the troubles from fine dust and sulphurous fumes. One result of the experimental work at Liverpool was that the chimneys were being made of high-percentage chrome steel, and it was believed that the dust and fumes difficulty at Liverpool could be got over at a cost of about 6s. 9d. per kilowatt.

Mr. W. M. Selvey regarded pulverised fuel burning now as thoroughly practicable, and thought it was only a matter of education of engineers, coupled with the solution of the dust and fume trouble, as to the extent to which it was increasingly adopted. As regarded chimneys, the use of a special cement lining for brick chimneys would probably prove as effective as the more expensive chrome steel chimneys just mentioned.

Mr. F. Forrest (Chief Electrical Engineer, Birmingham), said that he was installing the unit system instead of the bin and feeder system in the latest Birmingham plant, because of lower capital costs and maintenance charges. The same change from the bin and feeder system to the unit system was taking place in America. He urged the need for a greater degree of automatic control on boiler-house plant, as being as logical as on the turbine, owing to the possibility of 50,000 kW being suddenly disconnected under the "Grid" scheme. The use of water sprays, as at Derby, did not appeal to him as a final solution of the dust question, owing to the fact that there was not time, because of the velocity of the gases, for all the dust to become effectively damped down, and therefore a good deal of it would escape into the atmosphere. Moreover, he believed that the water spray method would lead to corrosion of the mild steel chimneys.

Dr. S. L. Pearce (Chief Engineer, London Electric Power Company), said that it would not do to advocate pulverised fuel for all conditions and situations. In the case of the Battersea power-house, when a decision had to be taken eighteen months ago, he came down on the side of the stoker. There was no difficulty in meeting all conditions with stoker plant with boilers up to 400,000 lb. evaporative capacity, but, above that, pulverised fuel would probably be best. His company had been carrying out research work as to dust and fuel emission, and a second Government report would be issued on the matter shortly. Moreover, he was reading a paper at the World Power Conference in Berlin in which that work would be discussed in detail. What was wanted was a solution that was both scientifically correct and economically practical, and he believed it would be found.

Mr. P. E. Rycroft (Babcock and Wilcox, Ltd.), remarked that, in the Electricity Commissioners' returns, there was no pulverised fuel station which came within 3 per cent. of the best stoker-fired stations. The paper, moreover recorded a thermal efficiency of 85 per cent., which, after deducting the power necessary for pulverising the fuel brought the figure down to something over 80 per cent., a figure which was quite easy to obtain with stoker-fired boilers. The author's results were largely due to geographical accident, because he was in the centre of a large coalfield and was able to buy coal apparently at 8s. 6d. per ton.

Mr. C. G. Morley New (Chief Electrical Engineer, Cardiff), also emphasised the last point made by Mr. Rycroft, and spoke of the dear coal, by comparison with that obtainable at Derby that he had to use. He also argued that it was fallacious to suggest that the improved results at Derby were entirely due to pulverised fuel. Some of it would have come about in the ordinary way by generally improved methods and without pulverised fuel plant; his own costs in the next few years, he estimated, would be better than those at Derby at present.

Mr. R. A. Chattock said that sufficient had not been made of the fact that pulverised fuel plant enabled the boiler-house staff to be reduced considerably. Three men in a pulverised fuel boiler-house could do the work of nine men in a stoker-fired boiler-house. It was not altogether fair to compare the published returns of stoker-fired plants and pulverised fuel plants, as Mr. Rycroft had done, because, as yet, there was not a completely pulverised fuel plant in operation in this country, and the figures in question related to stations working partly with pulverised fuel and partly with stoker-fired plant. Nevertheless, although the most recently published figures showed 21 per cent. thermal efficiency for the best stoker-fired station, at Hams Hall, Birmingham, 23 per cent. was being obtained. That, however, was not entirely due to pulverised fuel, but to the method of operating the turbines in order to save as many units as possible and get them back into the boiler. As an instance of the material that pulverised fuel plant would burn, he mentioned that during the last coalfields trouble he used pit mound material to the extent of 10,000 tons per week. It contained as much as 55 per cent. of ash, but it was possible to obtain full evaporation on the pulverised boilers, whereas on the stoker-fired boilers it was necessary to mix it with 50 per cent. of good coal, and then the boilers only gave 75 per cent. of their full output.

Mr. Lake replied to some of the points raised in the discussion. As to a combination of pulverised fuel and stoker plant, he said that there was a large station in this country working in that way, but he was informed that the stoker plant had been entirely abandoned. He had every confidence in his spray method of dealing with grit, and during the past nine months there had been no complaints at Derby. In connection with automatic control, he recommended a visit to Mannheim, possibly in connection with the World Power Conference, where, he said, automatic control had been installed on a very complete scale. He differed from Dr. Pearce in his suggestion that stoker-fired plant was best with boilers below 400,000 lb. evaporative capacity, because of the less degree of flexibility with stoker-fired plants, and the need there would be to handle large variations in load under the "Grid" scheme. In reply to Mr. Rycroft, he pointed out that the Electricity Commissioners' statistics, which had been referred to, related to the results at Derby when using 35 per cent. of stoker plant. Dealing with the cost of coal required for pulverising, Mr. Lake said that that all depended on how the colliery people were handled.

In the afternoon of Wednesday, May 28th, a visit was paid to the "Grid" substation at Brighton, which is now well on the way to completion, and is alive on the 33,000-volt side. It is the most advanced substation in the south and contains two 30,000-kVA Ferranti transformers, 132,000/33,000 volts. The high-tension switchgear is by the English Electric Company and the low-tension switchgear by Reyrolle, Ltd. The Brighton power station, which was also visited, is, of course, a selected station, and Eastbourne will be the first town in the south to be supplied by the "Grid." As a matter of fact, supply has been promised by October 1st, and Mr. Brydges, the Eastbourne Electrical Engineer and retiring President of the I.M.E.A., makes no mystery of the fact that, if the supply be not forthcoming, Eastbourne will be short of supplies this winter, permission to extend the plant at the Eastbourne power station having been refused.

The questions of electric heating of buildings and domestic water heating by electricity were discussed at the final technical meeting on Thursday, May 29th, when the meeting was held jointly with the Electrical Association for Women. In the first instance, Mr. J. W. Burr, Borough Electrical Engineer, Swansea, read a paper in which the details of a scheme for heating and providing hot water for a large hospital in his area were worked out, and he claimed that he was doing it profitably at 0·2d. per unit, a figure which was regarded as impossible by some engineers, owing to the fact that under the system of charging for "Grid" current it was more than probable that the charge by the C.E.B. will be higher than that figure.

A general discussion on domestic water heating was carried on in conjunction with Mr. Burr's paper, and perhaps the two striking general features of it were that the provision of electricity for domestic water was one of the biggest things in the way of prospective business the industry had ever tackled, and the need for cheapening and standardising apparatus to a far greater extent than was the case at present. The women who took part in the discussion complained strongly that for five years they had been agitating for a reduction in the cost of electrical apparatus for the home, but that nothing had been done.

In this connection it may be said that a great deal of attention was drawn to the new standard electric cooker which was shown at the Convention Exhibition for the first time. That, however, can only be regarded as a preliminary showing, because, in the first place, the cooker will not be in production until October, and will be modified in certain respects as the results of the criticisms of those who saw it for the first time. Again, although the price has been fixed to station engineers, there seems some doubt as to the actual retail charge for the cooker. The cooker is the result of the work of a Joint Committee of municipal and company electric supply authorities, the manufacturers, the power companies, and the Electrical Association for Women. The specification for the standard cooker was not finally settled until September, 1929, and a sample cooker was available for inspection in December last. The manufacture of this cooker—contemplated at the moment in two sizes, viz., for families of six persons and eight persons respectively, is being undertaken by the following firms:—Berry's Electric, Ltd., the British Electric Transformer Company, Ltd., Credenda Conduits Company, Ltd., the Falkirk Iron Company, Ltd., the General Electric Company, Ltd., the Hotpoint Electric Appliance Company, Ltd., the Jackson Electric Stove Company, Ltd., Revo Electric Company, Ltd., and Siemens Electric Lamps and Supplies, Ltd.

A party of members took advantage of the occasion of the Convention to visit the 600-acre all-electric farm of Mr. R. Borlase Matthews at East Grinstead, and saw some novel and up-to-date machinery. The most interesting exhibit was, probably, the Alfa-Laval electric milking machine, which was operated by one of the new General Electric Company's agricultural type motors. Hitherto, the electric motors on milking machines have merely replaced other prime movers. However, in the case of this machine, which is the first of its kind to be installed in this country, the valves of the milking bucket are electrically operated. In the older type milking machines the valves were controlled by a vacuum pipe line, the lag in which produced anything but a satisfactory valve cut-off indicator diagram. Another novel barn machine was the vertical-spindle disintegrator mill, with interchangeable heads, which heads make the machine universal for all classes of grinding, pulping decorticating and other similar work carried out on a farm.

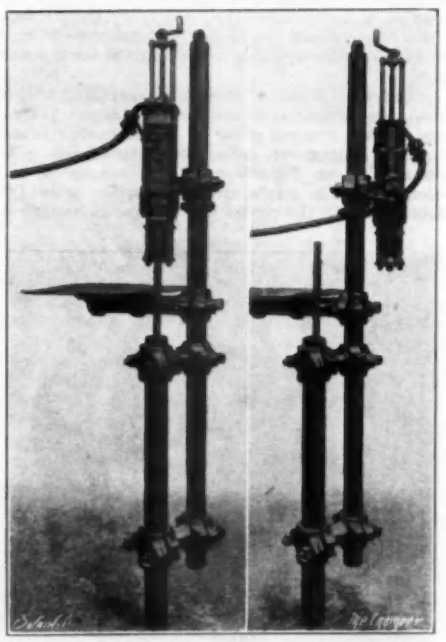
At the annual general meeting on Friday morning, May 30th, Mr. A. J. Fuller, Electrical Engineer to the Fulham Borough Council, was elected President, and, judging by the cordial reception given to an announcement that an invitation had been received to hold next year's Convention in Douglas, I.O.M., it would not be surprising if the Council accepted that invitation.

The annual dinner of the Association was held at the Grand Hotel, Eastbourne, on Thursday, May 29th, the principal guest being Colonel Sir Thomas Purves, President of the Institution of Electrical Engineers. Among the other guests was Mr. W. W. Lackie, one of the Electricity Commissioners. Although some 1100 people were attending the Convention, accommodation could not be found for more than one-third of that number, owing to lack of facilities, and it was not possible to divide the dinner into two parties in different hotels, as was done on a previous occasion.

Rock Drilling in Colombo Harbour.

A RATHER unusual proposition in the way of rock drilling has developed in the scheme for deepening the harbour at Colombo, Ceylon, which it is hoped, has been met by an equipment just sent out by the Climax Rock Drill and Engineering Works, Ltd., of Carn Brea, Cornwall. Mr. St. Stephens, of that company, recently passed through Colombo, and, in conjunction with the local harbour engineers, evolved the rig which we illustrate herewith.

At present there is only about 12ft. of water above the bottom of the harbour, as there are large bosses of rocks



RIG FOR DRILLING BLAST HOLES IN COLOMBO HARBOUR

protruding. These rocks, which must be blasted away, are covered with a layer of sand some 2ft. thick.

For the purpose of drilling the rock, preparatory to blasting, the Climax company has supplied an equipment of three drilling units, an air compressor and a drill steel sharpening machine. Of these units we illustrate one of the drilling units.

The general procedure which it is proposed to follow is that a 4½in. pipe should be sunk through the water and sand to rock bottom, reaching above high water mark, and stabilised either by guys or by a large flange at the ground level weighted by chain put in place by a diver. The drilling is to be effected down the centre of this tube, so at the top there is mounted a platform on which the operator will stand, and a frame for carrying a pneumatic rock drill of the makers' standard pattern.

In view of the necessity for replacing the drills as the depth of the hole increases, the drilling machine is mounted on a swinging bracket, so that it may be readily swung aside for the withdrawal or extension of the drill steel, as shown in the right hand view.

It will be interesting to hear how this simple contrivance overcomes the difficulty of drilling in the bottom of a harbour where the water is not tranquil.

THE construction of a pipe line from the Okhinski oil-fields to Siberia, Baikal Bay, where an oil port is to be built has been begun.

Large Transformers for New Zealand.

PART of the plant for installation in connection with the electric power scheme at Waitaki, which is being carried out to the plans of the Public Works Department, New Zealand, are seven 5500 kVA single-phase transformers of special design, which have been manufactured by the British Thomson-Houston Company, Ltd., Rugby. In the accompanying illustration is seen part of a train prior to its departure from Rugby with the seven units for this scheme. This shipment had a net load of over 90 tons, the weight of each transformer amounting to about 13 tons.

The transformers, which are of the oil-immersed water-cooled outdoor type, will form the initial installation of two 16,500 kVA three-phase banks, with one spare at the Waitaki Power Station, where, ultimately, the transformer installation will consist of five 16,500 kVA banks. Current from the alternators will be taken to the banks of transformers and stepped up from 11,000 volts to 110,000 volts, three-phase, 50 cycles, for feeding the transmission lines.

All the transformers will be delta-connected on the primary or 11,000-volt side and star-connected on the secondary, or 110,000-volt side, with the neutral point solidly earthed.

An interesting feature in connection with the plants

TRAIN LOAD OF 5500-kVA TRANSFORMERS

supplied for the Waitaki Power Station is that the 110,000-volt transformer bushings are interchangeable with those on the oil-immersed circuit breakers. These breakers are of similar construction to the 132,000-volt oil-immersed circuit breakers which this company has supplied for various sub-stations on the Scottish "Grid" Scheme. In addition to the oil-immersed circuit breakers, the B.T.H. switchgear for the Waitaki scheme includes a metering desk, and an indoor control board with voltage regulators and engine-room telegraphs.

THE CORNISH PORT OF PADSTOW.

THE fate of the little Cornish port of Padstow, which is one of the oldest in the country and at one time of considerable importance—it furnished several ships for the Siege of Calais, in 1346—is at the moment in the balance.

Across the harbour mouth stretches a big sand bank, known as the Doom Bar, a barrier which has been a dread and a nightmare to mariners in the past. The bar, however, served as a natural breakwater, and protection for the inner harbour, but it is being flattened out and swept away by the gales, with the result that the harbour no longer affords a safe anchorage. In fact, in heavy weather the ground seas sweep up the estuary of the river Camel, right to the old quay and the new dock, turning the waters there into whirlpools, and on occasions snapping the hawsers of vessels moored there.

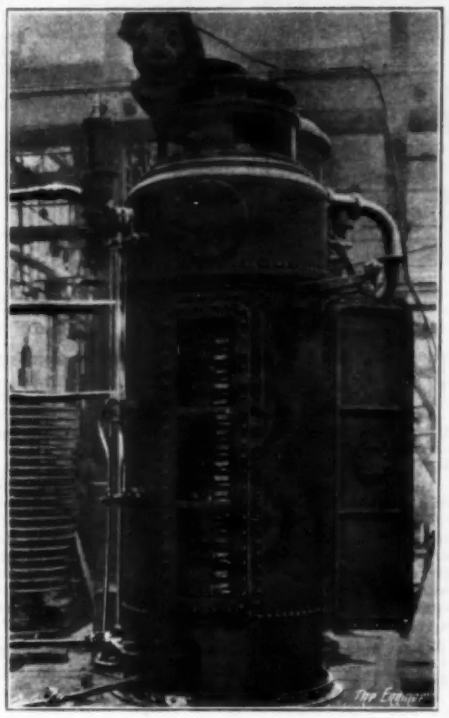
The position has become so serious that something must be done and done quickly if Padstow is to be saved as a port. The Harbour Commissioners, after a great deal of thought, helped by Lord Marks, who placed his services as consulting engineer at their disposal, have evolved a scheme, estimated to cost about £50,000, which it is considered will prevent Padstow passing out altogether as a port. The necessary protection, it is proposed, shall be provided by the building of a sea wall or breakwater, the stone for which has been offered from a local estate free of charge.

Where to find the money is the problem which now confronts the Commissioners, for the harbour undertaking has been carried on at a loss for many years, and but for the help of the Southern Railway Company, which meets this annual deficit, the port would practically have ceased to exist years ago. The visit to the place within the last few days of Sir Herbert Walker, general manager of the Southern Railway Company, with the chief engineer of the line and other leading officials, is regarded locally as an augury that the necessary financial arrangements will be secured. The site, it is understood, was fully explored by Sir Hrebert and his colleagues, and plans for the improvement and alteration of the harbour are now under consideration by the Southern Railway Company. Sir Donald Maclean, who is Member of Parliament for North Cornwall, has, it is stated, taken up the matter very enegetically, and it is believed that an offer of State aid, probably in the way of a grant by the Development Commissioners, will be forthcoming shortly.

It is generally admitted that failure to bring the present scheme to fruition means the doom of Padstow, which is one of the principal fishing ports in the West, and is notable for the considerable quantities of soles landed there. These fishes are caught so near the port that they are frequently on the quay within two hours of being taken in the trawls. Large numbers of trawlers from Lowestoft and Yarmouth fish out of Padstow during the season.

A New Type of Marine Evaporator.

IN the accompanying engraving we show a new type of marine evaporator with revolving disc-shaped elements, which is manufactured under the Englisch-Clarke, Chapman patents by Clarke, Chapman and Co., Ltd., of Gateshead-on-Tyne. In the ordinary type of tube evaporator for salt water, a common fault is the separating out of the salt from the sea water, which adheres to the outer surfaces of the tubes and interferes with the heat transmission. This defect is claimed to be entirely overcome in the new type of evaporator we are describing, as the salt is deposited in a relatively loose encrustation, which is easily removed from the revolving disc-shaped elements by stationary scrapers. The salt deposit finds its way to the bottom of the evaporator and is removed at regular intervals by running off a portion of the contents of the evaporator. The scrapers, which will be seen inside the open inspection door in the centre of the evaporator, are self-adjusting and they are easily removed. To the left of our illustration are seen the heating elements. They



ENGLISCH-CLARKE CHAPMAN EVAPORATOR

are mounted on a shaft, which is carried on a thrust bearing at the top of the evaporator and the drive is of the worm and spur gear type running in an oil bath. The driving motor is coupled through a two-part flexible coupling and for the larger sizes of evaporator the motor has an output of 6 to 7 brake horse-power.

The heating elements and the shaft which serves to admit steam to the discs, are made in sea-water resisting bronze. Water-separating baffles are fitted and there is a specially large water separator external to the evaporator which is filled with "Raschig" rings. This arrangement ensures completely dry vapour. The type of evaporator illustrated is claimed to maintain a constant evaporation, and it does not require special attention to keep the evaporator surfaces clean.

SIXTY YEARS AGO.

IN the early 'seventies opinion among scientific people was very undecided concerning the best direction to follow in pursuit of the problem of constructing a practical flying machine. Some favoured the inclined plane, but at least as many were impressed with the possibilities of the direct lifting air screw. The truth was that experimental knowledge concerning the forces in action on planes and screws was almost completely lacking. The Aeronautical Society was beginning to recognise that fact. At a meeting of that body held under the chairmanship of Mr. Glaisher on June 3rd, 1870, and reported in our issue of June 10th of that year, Dr. Smyth, of Maidstone, exhibited "an instrument for ascertaining the connection between velocity and pressure." Particulars of the design of this instrument were not given in our pages, but its presentation before the Society seems to have excited considerable interest and led one member, Mr. A. S. Harrison, strongly to advocate the establishment by the Society of an experimental fund. The Council, it appeared, had recently been considering the same proposal. The honorary secretary, Mr. Breary, was called upon to read an extract from the minutes of a Council meeting that had been held a short time previously at Stafford House. At that meeting Sir William Fairbairn called attention to the fact that little was known concerning the reaction or lifting power of various forms of screw blades, although experiments designed to afford the necessary knowledge could easily be made. Mr. Brook opposed the lifting screw principle, and argued that the most simple and obvious method of constructing a successful aerial machine was to employ inclined surfaces impelled forward horizontally. He had seen a striking experiment carried out on that principle, the motive power employed being a wound clock spring. He remarked, however, that scientists were ignorant of the sustaining power of inclined surfaces of different forms and areas, and that the lack of knowledge in that respect was a perpetual stumbling-block to experimenters. He said that as the weight and size of birds increased the relative wing area decreased, and suggested that it would probably be found that with inclined planes "the ratio of sustaining surface to weight or resistance was by no means in equal proportions." Mr. Glaisher mentioned that he had been making some experiments on the force developed by inclined surfaces of different contours when exposed to the wind, but his work had not as yet proceeded far enough to give definite results. It was then proposed that "an experimental fund should be raised by subscription, and that a suitable and well-finished anemometer should be constructed having the means of instantly setting various plane surfaces at any desired angle and capable of registering both horizontal and vertical force simultaneously for all degrees of inclination." This resolution of the Council, on being put before the members of the Society, was carried unanimously.

THE TURKESTAN-SIBERIA RAILWAY.

THE following account of the route of the new railway which is to make communication between the Turkestan system in the south and the Trans-Siberian Railway at Semipalatinsk, is taken from the *Novy-Vostock*. The line, it should be pointed out, skirts the northern frontier of India and the western boundaries of China. It is of considerable strategic interest.

The decision to construct a railway line that would connect Turkestan with Siberia was arrived at by the Soviet Union Government on December 3rd, 1926. The new line begins at the Semipalatinsk Station of the Omsk line, and cutting through the town of Semipalatinsk in a south-westerly direction, crosses the Yrtysh River, 4 miles further on. Then, passing the town of Alash from the west on the river Yrtysh, turns towards Kokpekty, at a distance of 100 kiloms., following the valley of the Tchar-Gurbar River. Thence it heads westward into the valley of the Djarma River. After crossing the Ashtchi-Su River the line climbs to the watershed of the basins of the river Yrtysh and the Lake Balkhash, descending to the town of Sergiopol. Running along the north-eastern shore of Balkhash it crosses the river Karatal, and, following first the valley of the latter and then that of the river Bizh, it winds upward amid the Maly-Sary chain on the eastern side, touching the Ili settlement, near which it crosses the river Ili. From there the line heads almost straight in a southern direction towards the Alma-Ata Station, situated on the northern side of the town. From the Alma-Ata station the line, which here is traced northward from the Frunze-Alma-Ata postal track, crosses a number of rivers, viz., Kaskelen, Tchemolgan, Kargaly, and others; through the valley of the river Kopa, it crosses the Ala-Tau chain by the Tchokpar Pass. Descending from it in the direction of the river Tchokpar, it crosses the river Tchoo, not far from the Novo-Troitskoe settlement, whence, following a south-western direction, it approaches the river Kurga-Ta, and running along its valley it reaches the station of Lugovaia, situated at the 424th kilometre of the Arys–Pishpek–Orenbourg branch of the Tashkent Railway. The entire length of the line is 1481 kiloms.

THE METAL CRYSTAL.

IN his discourse delivered before the Royal Institution on Friday, May 30th, Sir Harold Carpenter, F.R.S., explained that when prepared by one of the usual methods, metals and alloys consisted of an aggregate of small allotriomorphic crystals. Pure metals usually consisted of a large number of similar crystals. Alloys were sometimes composed of one type of crystal, though usually they contained two or more different kinds. In both cases, metals as ordinarily prepared, contained anything from about one hundred thousand to several millions of crystals per cubic inch. Their properties accordingly were the properties of aggregates and were therefore composite.

In all metals, however, the individual crystal was the unit of which the aggregate was built. It was therefore the simplest form of metal. From a scientific standpoint the study of individual metal crystals should precede that of aggregates. That enabled any particular property of the metal crystal itself to be studied, the only variable being its orientation. It was the realisation of that fact which had given rise in recent years to definite attempts on the part of investigators to prepare single metal crystals. Success had been achieved in three different ways:—

(1) By the production of the crystal from the vapour phase;
(2) By its production from the liquid phase;
(3) By the conversion of the solid metal in the ordinary polycrystalline aggregate into a single crystal.

Each of those was an example of controlled cystallisation. The investigation of any particular metal divided itself into three parts:—(*a*) The production of the crystal itself; (*b*) the determination of its orientation; and (*c*) the study of its properties. The last category might be divided into two sub-categories according as the investigation (1) did or (2) did not involve the distortion of the crystal.

It was clear from the results obtained that both the mechanical and physical properties of the single metal crystal were, in the majority of cases, directional. That fact was more strikingly illustrated in the mechanical tests, because the single-crystal test pieces underwent distortion and assumed new and striking forms. In both categories, however, the properties of the single crystal differed from those of the crystal aggregate, depending upon its particular orientation. Single-crystal alloys had been investigated to a less extent, but in so far as evidence was available it indicated that the same held for them. Future research would involve the controlled production of single crystals in particular orientations. Such knowledge would form the basis of the scientific manufacture of metals and alloys possessing properties which could be specified with accuracy and certainty.

6000-kVA THREE-WINDING TRANSFORMER

THE METROPOLITAN-VICKERS ELECTRICAL CO., LTD., ENGINEERS

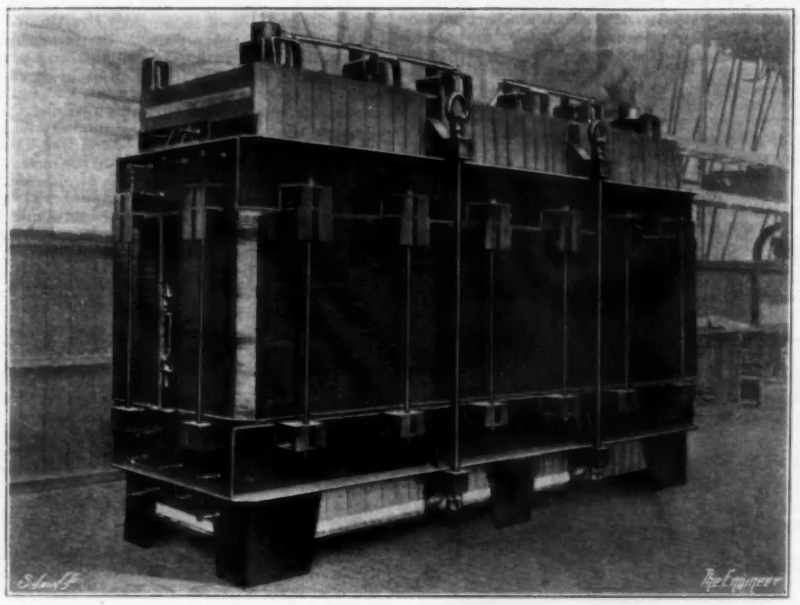


FIG. 1

Three-Winding Transformers.

In a leading article on Modern Transformers, appearing in our issue of December 20th, 1929, we referred to the various applications of three-winding transformers. Usually, these transformers are required to give either full output or a large proportion of it, on each secondary winding, and are frequently required to operate when the supply is applied to the high voltage winding in stepping down to the intermediate and low voltages or when the supply is applied to the intermediate voltage winding in stepping up to the high voltage and down to the low voltage. It may also be necessary to feed the low tension winding in order to step up to the intermediate and high voltages. Under these conditions it is necessary for the impedance voltage between any pair of the three windings to be

FIG. 2—THREE-WINDING TRANSFORMER ON TEST BED

reasonably high, and this requirement the Metropolitan-Vickers Electrical Company finds usually necessitates the employment of windings of the sandwich type. For extra high voltages with windings of this kind the shell type of transformer is most readily adaptable, and the three-winding transformers under consideration are all of the shell type, with sandwich windings, and are all designed to operate under the conditions mentioned. A three phase bank comprising three 7333-kVA single-phase units connected 120,000-volts star/42,000 delta/21,000 delta has been constructed by the Metropolitan-Vickers Electrical Company. The windings are designed to give a total output of 22,000 kVA, which may be obtained from any one of the three windings individually or as the sum of the outputs of any two windings when loaded simultaneously. The windings therefore correspond to an equivalent capacity of 33,000 kVA.

The alternative operating conditions are :—

120,000-volt supply,	42,000 volts and/or	21,000 volts secondary
42,000	,,	120,000	,,	21,000	,,
21,000	,,	120,000	,,	42,000	,,

The approximate impedance voltages are :—

High voltage-intermediate voltage	7·7 per cent.
Intermediate voltage-low voltage	7·9 ,,
High voltage-low voltage	8·4 ,,

The Metropolitan-Vickers Electrical Company has also built 6000-kVA, 84,000-volt delta/42,000-volt star/21,000-volt star three-phase transformers. As in the previous case, the full output, viz., 6000 kVA, may be obtained from any one of the three windings individually or as the sum of the outputs of any two windings, when loaded simultaneously, and the windings therefore correspond to an equivalent capacity of 9000 kVA. The alternative operating conditions are as follows :—

84,000-volt supply,	42,000 volts and/or	21,000-volt secondary
42,000	,,	84,000	,,	21,000	,,
21,000	,,	84,000	,,	42,000	,,

The approximate impedance voltages are :—

High voltage-intermediate voltage	4·16 per cent.
Intermediate voltage-low voltage	3·94 ,,
High voltage-low voltage	4·31 ,,

The illustration, Fig. 1, shows one of these transformers

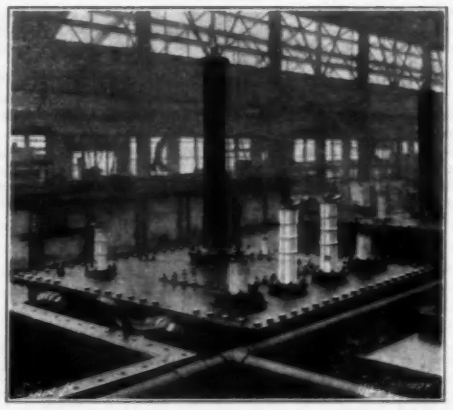


FIG. 3—TRANSFORMER TERMINAL BUSHINGS

removed from its tank, whilst Fig. 2 shows one of these transformers on the test bed. The transformers are water-cooled, and in order to facilitate erection on the site, where the headroom and handling facilities may be limited, the tank is built in three sections.

Another example is a 25,000-kVA bank of three 8333-kVA single-phase units connected, 104,000-volt star/33,000-volt star/6600-volt delta. The high-voltage winding is designed to give a continuous output of 25,000 kVA, while the intermediate and low-voltage windings are each designed for a continuous output of 15,000 kVA, and the windings therefore correspond to an equivalent capacity of 27,500 kVA. If the windings are not loaded beyond these limits the following alternative operating conditions are possible :—

104,000-volt supply,	33,000 volts and/or	6,600-volt secondary
33,000	,,	104,000	,,	6,600	,,
6,600	,,	104,000	,,	33,000	,,

The approximate impedance voltages are :—

High voltage-intermediate voltage	6·6 per cent.
Intermediate voltage-low voltage	5·1 ,,
High voltage-low voltage	6·6 ,,

Fig. 3 shows the terminal arrangement of one of these single-phase units. A 45,000-kVA transformer bank, composed of three 15,000-kVA single-phase, 115,000 star/6600-volt delta/2200 delta units has also been supplied. The high-voltage winding is designed to give a continuous output of 45,000 kVA, the intermediate voltage winding 39,000 kVA, and the low-voltage winding 15,000 kVA. The windings therefore correspond to an equivalent capacity of 49,500 kVA. Provided that no winding is loaded beyond these limits, the following alternative operating conditions are possible :—

115,000-volt supply,	6,600 volts and/or	2,200-volt secondary
6,600	,,	115,000	,,	2,200	,,
2,200	,,	115,000	,,	6,600	,,

The approximate impedance voltages in this case are :—

High voltage-intermediate voltage	13 per cent.
Intermediate voltage-low voltage	6 ,,
High voltage-low voltage	15 ,,

Another example is a 20,000-kVA, 110,000-volt star/33,000-volt star/6600-volt delta, three-phase bank, comprising three 6667-kVA single-phase units. The high-tension winding in this case is designed to give a continuous output of 20,000 kVA, the intermediate voltage winding 9000 kVA, and the low-voltage winding 15,000 kVA. The windings therefore correspond to an equivalent capacity of 22,000 kVA. Provided that no winding is loaded beyond these limits the following alternative operating conditions are possible :—

110,000-volt supply,	33,000 volts and/or	6,600-volt secondary
33,000	,,	110,000	,,	6,600	,,
6,600	,,	110,000	,,	33,000	,,

The approximate impedance voltages are :—

High voltage-intermediate voltage	6 per cent.
Intermediate voltage-low voltage	6 ,,
High voltage-low voltage	10 ,,

Canadian Engineering News.

(From our own Correspondent.)

Tar Sand Projects.

Two different schemes presented to the Canadian Government and in process of being approved for the extraction of hydrocarbons from the great tar sand deposits at Fort McMurray, in the province of Alberta, will each involve an outlay of approximately 2,000,000 dollars, apart from experimental work costing 20,000 dollars. One scheme is presented by United States interests, and the other by Canadian interests. It is likely that an Order in Council will be passed, approving a code of regulations under which both concerns will receive concessions and be empowered to conduct experiments in utilising the tar sands for different kinds of hydrocarbons. The enterprises, if successful, promise to develop into important affairs. The United States concern will use the McLay process, while the Canadian firm will employ a centrifugal method. Recently a board of technical experts investigated the matter and evolved a series of regulations, mainly outlining conditions under which the concessions would be made. It is anticipated that thirty-eight hundred acres to each company is the grant likely to be made.

Transmission of Electric Power.

Representing the beginning of the Saskatchewan Government's proposals for transmission of electric power throughout the province, announcement is made that over 500 miles of transmission lines will be constructed this year at an estimated cost of 2,000,000 dollars. Lines radiating in three directions from the city of Saskatoon, together with a long line north-westerly from Moose Jaw, will be included in the 1930 programme.

Railway Proposal.

The Hudson Bay Western Railway Company has applied to Parliament for the right to construct a railway across the northern parts of the provinces of Manitoba and Saskatchewan. The proposed line would run from Fond du Lac, on Lake Athabasca, in the province of Saskatchewan, thence easterly by the most feasible route to Fort Churchill, in the province of Manitoba. A group of British capitalists controlling mineral deposits north of Lake Athabasca is understood to be behind the application. Fond du Lac is near the north-west corner of Saskatchewan on Lake Athabasca and nearly 500 miles west of the eastern terminus of the proposed line at Churchill, the new port on Hudson Bay. With the exception of the Hudson Bay Railway, terminating at Churchill, there is no other railway line coming within 200 miles of the northerly latitude the proposed line would traverse.

Budget Favours British Aircraft.

Manufacturers of British aircraft in Canada are favoured by the recent Dominion Government Budget. Formerly, the duty on British aircraft entering Canada was 15 per cent., but it will be reduced to 10 per cent. on July 1st. Two years ago the arrangement was made that British-made engines entering Canada for incorporation in machines being assembled in the Dominion should come in duty-free, but that on July 1st, 1930, a duty of 15 per cent. would be charged, with 25 per cent. intermediate tariff and 27½ per cent. general tariff. The new tariff provides that the duty on British aircraft engines entering under the preferential tariff is to be 10 per cent. only, while the intermediate and general tariffs remain as planned. In the year 1929 the value of aircraft engines imported to Canada was 891,200 dollars, of which 522,700 dollars worth came from Great Britain and 368,500 dollars worth from the United States. Imports of aircraft totalled 2,388,700 dollars, of which 1,568,000 dollars worth came from the United States, and 733,500 dollars worth from Great Britain.

Absorption Plant.

The Research Engineering Company intends to build a 300,000-dollar absorption plant in the Turner Valley oil field of Alberta to handle the waste gas from independent companies, including the natural gas from the McLeod and Okalta wells. An agreement has been reached with the Research Company, which will take up

to 25,000,000 cubic feet of gas per 24 hours. McLeod will receive from this 16¾ per cent. of the total gross proceeds of all the petrol extracted from the waste gas and 50 per cent. of the proceeds of the dry gas.

Large Electric Shovel.

There has recently been delivered to the Beauharnois Power Company, at the site of the new power canal on the St. Lawrence River, the largest electric shovel ever used in Canada. It took nineteen railway cars to convey it from the factory in Marion, Ohio, where it was built by the Marion Steam Shovel Company. It is known as a Type 3520 "Marion" full revolving electric shovel and is mounted on four railway trucks. It has a boom 93ft. 6in. long, a dipper handle 60ft. 6in. long and a dipper of 8 cubic yards capacity, giving a maximum height of dump 67ft. 6in. above top of rail and a maximum radius of dump at maximum height of 97ft., with an approximate working weight of over 1,100,000 lb. This shovel is to be used at the power-house site which is mostly rock.,

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Blast-furnacemen Adamant.

THE announcement by the Central Pig Iron Producers' Association that there would be no change in the current price of pig iron was received by users with much displeasure. That furnacemen should thus harden their hearts against their customers had hardly been anticipated, especially seeing that the latter had taken such pains to bring home to the producers the necessity for a lowering of iron values. They contend that the producers' organisation is being used to maintain prices at an artificial level, for they say that the situation has undergone such a marked change since the present level of prices was fixed that prices are to-day at variance with actual trade conditions. It is fairly evident that blast-furnacemen fear higher production costs as a result of the Coal Bill, but it is properly pointed out that they would not have surrendered their freedom to take measures of self-preservation if in the meantime they had shared with their customers the benefits of the savings that are now being made as a result of cheaper coke. It would appear as though they are relying upon a revival in business at the foundries, which will force the hands of the consumers, and compel them to buy pig iron at the furnaceman's figure. Users this week say that a substantial volume of business which would have been released had prices been eased, will continue to be held up, and that they intend to continue their policy of hand-to-mouth buying. They certainly will not enter into forward contracts on the present basis of prices. Merchants and consumers consider that furnacemen having reaped the advantage of cheaper coke, might have seen their way to give a stimulus to the market by a reduction of a few shillings per ton, and they accuse them of "high-handed action," which will further postpone that revival in trade which is so keenly desired by producers and consumers alike. Buying this week has been of a most restricted character, and purchasers have been compelled to pay the old prices, namely, Northamptonshire forge, £3 1s.; No. 1 foundry, £3 18s.; No. 2, £3 17s.; No. 3, £3 15s.; No. 4, £3 14s.; Derbyshire forge, £3 14s. 6d.; No. 1 foundry, £4 1s. 6d.; No. 2, £4 0s. 6d.; No. 3, £3 18s. 6d.; No. 4, £3 17s. 6d.—delivered at stations in the Black Country.

Finished Iron.

In the Staffordshire finished iron trade business proceeds as of late, and ironmasters continue to look for better times. Except in the best bar department, however, it is impossible to see how improvement is to be brought about. At the moment producers are engaged in a struggle to keep works in operation. In the case of marked bars, conditions are fairly satisfactory, some fortunate firms being steadily engaged and having substantial orders on their books. There is no need in this department to worry about prices, and the basis of £12 10s. per ton is firmly adhered to. A few orders are coming to hand for Crown bars, but they are of no substantial volume, and makers' prices vary between £10 and £10 7s. 6d. per ton. In the nut and bolt bar branch, continental competitors secure the bulk of the business. Belgian No. 3 iron has been a severe and successful competitor in this district for a long time, and with the continental works all anxious for orders, prices are going even lower. This week it is stated that No. 3 iron has been offered as low as £5 f.o.b. Antwerp, which even when carriage is added is under £6 a ton delivered here. The lowest price at which Staffordshire ironmasters are prepared to sell nut and bolt bars is £9 to £9 5s. per ton. Wrought iron strip is not in such regular request as it was. The Black Country tube works have of late felt the general trade reaction, and demand has fallen away considerably. The weldless tube firms have still moderately good order books, however. Iron tube strip continues to be quoted £11 2s. 6d. per ton.

Steel.

Steel works complain of the shortage of orders alike, for finished and semi-finished material. In the structural branch, business is decidedly unsatisfactory, specifications being very scarce. Midland consuming engineers have, for the most part, only small structures in hand, and tonnages of steel required are small. Transactions are at the Association basis of £8 7s. 6d. for angles, £8 10s. for joists, and £8 17s. 6d. for plates. Boiler plates are in fair request at £9 12s. 6d. upwards. Local re-rollers report sales to be declining. Their figure of £8 to £8 5s. for small rolled bars is being "cut" by continental agents, and competition is becoming keener. Billets are in no better demand than they have been of late, and values range from £6 upwards. The demand for steel strip is comparatively good, but here, again, continental competition is evident, strip being offered at £6 17s. 6d. delivered, as compared with £8 5s. upwards asked by local producers. Steel scrap remains a weak market.

Galvanised Sheets.

Some improvement in the Indian demand for galvanised sheets is welcomed by local mills this week. The bulk up to now is nothing out of the way, but the orders so far received have come at a very opportune moment, and are therefore doubly welcome. There is little movement in other overseas markets, however, and the home trade, though well maintained, is small compared with export consumption. A few mills are booked up to July, but the majority of them are able to meet the demand for quick delivery, which is a stipulation attached to most of the business now offered. Values continue unchanged from last week. Little interest is displayed in this area just now in tin-plate. Users are placing very few orders. The premium of 3d. which manufacturers have been getting on the 18s. basis for primes is not uniformly insisted upon.

Automobile Engineering.

Automobile engineers in the Coventry, Birmingham, and Wolverhampton districts are not generally pleased with the situation existing at date. Business is much below expectations in practically all branches, and one very important firm has this week stopped some hundreds of hands. The improved buying after the Budget announcement in April has not been maintained, and makers of light and medium private cars could do with additional orders. The demand for motor omnibuses and coaches is satisfactory, and the local manufacturers associated with this branch have no reason to complain of the orders which are coming their way.

Midland Manufacturers' Protest.

A strong protest against the passing into law of the Hours of Industrial Employment Bill was made this week by the Midland Council of the National Union of Manufacturers. It is contended that the measure would tie the hands of manufacturers and increase the cost of production. Moreover, it would add further and unnecessary taxation at a time when the burden of taxation is crushing the individual life of the nation. The Government is urged to refrain from further restrictions on hours and conditions of work until hours and conditions of work in foreign countries are brought to the level already existing in Great Britain.

Imported Hollow-ware.

Midland, and in particular East Worcestershire, manufacturers of hollow-ware are fervently hoping that the application made this week under the Merchandise Marks Act for an Order in Council compelling the marking of imported wrought enamelled hollow-ware for domestic use, whether of iron or steel, will be successful. These articles, which for two years have been subject to a Safeguarding duty, have to contend with very severe foreign competition, and so similar in shape, style and design are the foreign goods that it is contended that even dealers in the trade have difficulty in distinguishing them from native articles. It is said to be impossible for the retail purchaser to tell when he is buying imported goods. It is asked that foreign wrought enamelled hollow-ware should be marked at the time of manufacture upon the enamel, and that the mark should be printed before fusing. The application has the unanimous support of local manufacturers, and at the hearing of the Standing Committee, both the Wrought Hollow-ware Trade Employers' Association and the National Union of General and Municipal Workers stressed the necessity for such an order.

Rolling Stock Contracts.

The orders for rolling stock for overseas railways reported last week as having been secured by Midland firms have since been added to, for this week comes the news that the Metropolitan-Cammell Carriage Wagon and Finance Company, Ltd., of Saltley, Birmingham, has received an order from the San Paulo (Brazilian) Railway Company, Ltd., for 100 40-ton open steel bogie wagons. It is also to supply three bogie carriage underframes to the Nizam's Guaranteed State Railway. The Avonside Engine Company, Ltd., has received from the Peruvian Corporation a contract for a 4–8–0 type metre-gauge locomotive; while the Patent Shaft and Axletree Company, Ltd., of Wednesbury, has an order for points and crossings from the La Guaira and Caracas Railway, Venezuela.

£30,000 Order for Black Country Firm.

John Thompson Water Tube Boilers, Ltd., whose works are at Ettingshall, Dudley, and Bilston, has secured an order from the Metropolitan Water Board for three complete boiler units for Surbiton pumping station, to the value of nearly £30,000. The contract is the second placed with this firm from the London authority, the first being a contract of roughly the same value for the pumping station at Deptford. In addition, the firm will supply air pre-heaters, feed pumps, ash-handling and coal-handling plant, boiler-house piping, mechanical chain grate stokers, water softening and de-aerating plant, evaporators, and tanks.

Loss on Coal at Cannock.

For the first time for several months, the Cannock Chase coal trade ascertainment shows a loss. There was an average loss on all coal produced in the area during April of 1·03d. a ton, compared with a profit of 1s. 0·96d. a ton in March. The owners' accumulated deficit, which was £1,172,312 a month ago, is now stated to be £1,187,094. The wages of Cannock Chase and Pelsall coal miners in June, which are based on the results of industry for the months of February, March and April, will remain at the minimum rate of 42 per cent. on the 1911 basis, but the owners' real ability to pay is only 32·98 per cent., the balance having to be met by the coalowners.

Warwickshire Coalfield.

In the Warwickshire coalfield the position is becoming slightly worse, but it is due entirely to seasonal causes. Wages of Warwickshire miners have dropped 1 per cent. for the month of June, the ascertainment being on the 46 per cent. basis, compared with 47 per cent. for May and 48 per cent. for April.

Unemployment.

Unemployment in the Midlands becomes gradually worse. A fortnight ago the figure stood at 240,184, a week later it had improved to 237,319, but the latest returns show further retrogression, the total having risen by 3048 to 240,367. The districts in which increases are reported are Bilston, Coventry, Dudley, Leamington and Warwick, Oldbury, Redditch, Stoke-on-Trent, Stourbridge and Brierley Hill, Tipton, Wednesbury, and West Bromwich. At Birmingham the total of 36,512 is some 300 lower than it was a week ago. Leicester, Nottingham, and Northampton all show decreases, as do Wolverhampton, Walsall, Cradley Heath, and Smethwick.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Looking to Russia.

IMPORTANT sections of the Lancashire engineering trade and other branches the interests of which are largely interdependent, are hopeful of participating to an appreciable extent, in addition to those that have already been placed, in the contracts that are being distributed by the Russian Trade Delegation. Mr. S. G. Bron, the Russian trade representative, spent a busy time in the Manchester area during the first three days of this week, addressing on Monday a special meeting of members of the Manchester Chamber of Commerce, and, among other official visits, touring the works of Mather and Platt, Ltd., electrical and general engineers, Newton Heath, Manchester; the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park; the Churchill Machine Tool Company; Platt Bros., Ltd., Oldham, and Tweedales and Smalley, Ltd., Rochdale. Large orders for electrical equipment and machine tools have already been placed locally, and textile machinists in Lancashire, the majority of whom during the past few years have had a disappointing experience, especially in the domestic market, are hopeful of securing welcome additions to their order books from Russia.

The Steel and Coal Mergers.

An important step towards the actual formation of the Lancashire Steel Corporation and the Wigan Coal Corporation, a development which was mentioned in this column last week, has been taken by the shareholders of the Wigan Coal and Iron Company, Ltd., who, at an extraordinary general meeting, approved the scheme for the amalgamation of the Pearson and Knowles Coal and Iron Company, Ltd., the Wigan Junction Colliery Company, Ltd., the Moss Hall Coal Company, Ltd., and the Wigan Coal and Iron Company. An application for confirmation by the Railway and Canal Commissioners of the amalgamation of these companies with the Partington Steel and Iron Company, Ltd., was also approved. Sir W. McLintock said that the merger was conceived on sound financial lines and should produce efficiency in manufacture as well as in selling. The concentration of iron and steel manufacturing plant at Irlam, near Manchester, on the banks of the Ship Canal, instead of at Wigan, would, he declared, give great advantages in competing for various overseas markets.

Extending Liverpool's "Underground."

A scheme to extend the tunnel under the River Mersey so as to link up the stations of the Mersey Railway Company with all the termini in Liverpool, has been approved by a town's meeting held under the auspices of the Industrial Transport Association, and a resolution expressing approval has been forwarded to the Ministry of Transport, Liverpool City Council, the various railway companies concerned, and Members of Parliament representing constituencies in Liverpool, Birkenhead and other Merseyside areas. The manager of the Mersey Railway Company—Mr. Jos. Shaw—said that he had prepared a scheme for linking up the Mersey Railway with other termini. A line would have to be run under the new Mersey Tunnel at two points, and one station would have to be constructed 140ft. below and two others 90ft. below ground level. Mr. Shaw estimates the cost at about £1,500,000.

Short Time or Smaller Staff?

A decision of the management of the London, Midland and Scottish Railway Company, to reduce the staff at Crewe works by 200 men, mainly fitters, has, it is reported, resulted in an alternative proposal being submitted to the directors by the workpeople, who are prepared to submit to a further period of short-time working if no discharges take place.

A Better Showing.

Although not yet back to the dividend-paying stage, the results of the financial year to the end of March of Royce Ltd., electrical and mechanical engineers, Manchester, show a marked improvement compared with recent years. After providing for trade expenses, depreciation and repairs and replacements, the accounts show a net profit of £293, against losses in the three previous years of £7151, £3544 and £7621 respectively.

Non-ferrous Metals.

Tin has been the chief victim of bearish influences on the non-ferrous metals market during the past week, renewed evidence of statistical weakness having brought prices down to a lower level than has been experienced since before the war. An addition of about 3800 tons to the already heavy visible supplies of the metal was a good deal more than the market could stand without flinching, and present prospects point to a further addition when the

statistics for the current month make their appearance at the end of June. The market has not been free from a fair weight of speculative buying, but, even so, the turnover in tin during the past week has been appreciably less than it is normally. The loss on balance has been in the neighbourhood of £6 a ton, and it is interesting to note that the prices current at the time of writing are not much short of £80 a ton below those ruling at the end of last July, when values at about the height of the "ramp" were well above the £200 mark. There has been a marked diminution also in the demand for all classes of copper, although in this case the loss has amounted only to about 10s. a ton. Not much buying interest has been displayed in lead, which, however, has been well held at the previous week's level, though spelter has lost last week's gain and is back to where it was a fortnight ago.

LATER.

The Manchester market for old non-ferrous metals continues weak, and largely nominal in view of the existing uncertainty, and transactions this week have been of limited extent, both in the aggregate and individually

Iron and Steel.

A slight increase in business has been noted in the Lancashire pig iron market this week, following on the decision of Midland producing interests not to alter prices. This decision, however, was anticipated by sellers, and in few instances is there evidence of any disposition on the part of users to cover more than their needs over the coming month. On the other hand, the firm stand which makers have taken tends to reduce the hope, so far as consumers in this part of the country are concerned, of being able to get supplies of raw materials at more favourable rates. For delivery in the Manchester district, Staffordshire and Derbyshire brands are quoted at 77s. per ton, Scottish at about 94s., and West Coast hematite at 90s. The demand for bar iron continues on a restricted scale, with Lancashire makers asking £10 5s. per ton for Crown quality material and about £8 15s. for No. 2. Locomotive engineers are calling for steel in fair quantities against contracts, but in most other departments, particularly constructional engineering, boiler-making, textile machinery manufacture, and general engineering, buying interest is exceptionally slow and delivery specifications cover only small tonnages for the most part. Re-rollers are offering small bars at the reduced levels of a week ago, but in all other sections of the market for home-produced steels values are maintained.

BARROW-IN-FURNESS.

Hematite.

It may be taken that the cut in price for hematite pig iron reflects the weakness of the market, but it is too early to see what effect the reduction will have. Orders booked many months ago for deliveries are now being completed and another month or so will see practically all contracts ended. If the new prices do not tempt buyers to place orders, then it means a reduction of output. The requirements of the steel departments are, as regards the future, not very bright, and that will naturally have a tendency to put more iron on the market unless furnaces are damped down. Stocks at some of the works are increasing. The American and continental trade continues, but the total tonnage shipped recently has not been heavy. The local demand for iron ore is maintained, but the outlook is uncertain. The steel market is dull. Barrow is engaged in the Siemens, rail bar and hoop departments, but the 11,000-ton order for Africa is nearly completed and fresh contracts would be welcome. A shipment of about 2000 tons of rails for Africa is due from Barrow almost immediately.

Barrow Gasworks.

At present the Barrow Corporation Gasworks consist of two separate units, one, the original in the town and the other, a modern plant at Roose, which is on the outskirts. The Corporation is proposing to centralise the works at Roose, and this week an inspector of the Ministry of Health held an inquiry into an application to borrow £47,100 for that purpose.

SHEFFIELD.

(From our own Correspondent.)

General Outlook.

THE commercial steel trade in Sheffield and district is adversely affected, first by one thing and then by another, and shows no signs of surmounting its difficulties. Now, the approach of the Whitsuntide holidays is causing a further shrinkage in business. There is always a restriction in the buying of raw materials before a holiday, and specifications during the past week have been severely curtailed. The holiday, like that of Easter, will probably be longer than usual, and, as stocktaking at many works will be in operation by the end of this month, the chances of a revival will be further reduced. Pease and Partners, Ltd., of Darlington, have received an order from a Sheffield firm for 18,500 tons of hematite pig iron, which they are only making, at present, at their Normanby works, but the period of delivery is much longer than usual, being spread over five years. In both acid and basic steel, the turnover tends to decrease, and many of the local furnaces are out of commission. North Lincolnshire, which up to a few weeks ago was doing extremely well in basic steel, reports now that business has dropped to the level at which only immediate requirements are ordered. The Frodingham works are, however, restarting two of the melting furnaces which were stopped a month ago.

Railway Steel.

Employment in the branches making railway axles, tires, and springs, although not by any means on a satisfactory scale, keeps steady. For some little time now, the home railway companies have been taking increased supplies, while work for South Africa and the Argentine is on a moderate level. There is, however, very little being done with India and the Eastern markets. The trade is also seriously affected by the great shortage of wagon building in this country. Mr. G. H. Cowen, chairman of George Turton, Platts and Co., Ltd., a Sheffield firm which is largely engaged in the manufacture of buffers and other railway material, has just returned from a visit to the Argentine, Peru, and Uruguay. He points out that the principal railways there were established with British capital and that Sheffield gets the bulk of the orders for material. Nevertheless, other countries, and particularly America, are trying hard to get in there. Recently, after many attempts, the Americans secured control of one of the smaller railways, and our manufacturers and capitalists, he says, will have to be very much alive to maintain our position out there. The India Store Department has recently invited tenders for several supplies, including 175 steel double-side tipping wagons, while the Nijam's State Railways Board is in the market for helical springs.

Special Steels and Tools.

Several of the leading firms are enjoying a fairly good, though reduced, trade in special steels, not only with the home market, but with overseas. There is a fairly healthy tone about the engineers' small tools trade, which did well last year, and is still better placed than many other branches. Poor reports come from many of the file factories, but a few are receiving good orders. The file work on hand includes some for Russia, but the quantity is not large. There is not much activity at the engineering and light castings foundries. Transactions in steel-making alloys are very limited, except in the case of ferro-chrome suitable for use in the manufacture of stainless steel, fairly large quantities of which are going into consumption. The call for automobile steel and parts is large, though not up to the levels of the past few years. Sheffield continues to supply good quantities of special steels for the parts of aircraft that are subjected to the most severe stresses, and the city is usually interested in any new exploit in aviation that is achieved. This is the case in connection with Miss Amy Johnson's remarkable flight to Australia. The valves in the engine of her Gipsy Moth aeroplane were manufactured from special steel made by Kayser, Ellison and Co., Ltd., of this city, who also supplied valve steel for the engine used by Mr. Bert Hinkler on his Australian flight. In the section for farm tools there is a good demand for such as are suitable for beet cultivaton, but in other lines business in flat, both at home and overseas. Sales of garden tools have improved since the arrival of summer-like weather, but the season's turnover is not likely to reach the level of last year's. Several firms making twist drills and cutters are maintaining a fairly good turnover, but are far from busy. The demand for circular saws and hand saws remains restricted, and only a few firms are able to report moderately good order books. The hacksaw trade is healthy.

A Foundry Concentration.

The English Steel Corporation, Ltd., Sheffield, has now concentrated most of its steel casting work at the Grimesthorpe Foundry, formerly connected with Cammell Laird and Co., Ltd. The foundry is laid out for the weekly production of about 200 tons of castings, and the current issue of *Vickers' News* gives a full description of it. It is stated that the foundry is producing all kinds of carbon steel, manganese steel, nickel-chrome, and chrome steel castings. In manganese steel the foundry specialises in liner plates, rock-crushing machinery details, cams, tappets and rolls. Large quantities of castings are being turned out for dredger works, such as buckets, tread and cheek plates, top and bottom tumblers, &c. Turbine castings in manganese steel, magnet cases and yokes, and quantities of railway castings, such as axle-boxes and buffers, are also being manufactured. The smallest casting produced so far, weighed about 7 lb. The largest, in the "as cast" condition, weighed 140 tons, reduced to 95 tons after being machined. This was an anvil block for a 5-ton Massey friction drop stamp.

Cutlery and Plate.

Only a minority of firms in these trades have satisfactory order books. The majority are very slack, and the state of trade generally leaves so much to be desired that, in the opinion of many members, the month of April was the worst they had known for many years. Normally, overseas trade maintains a fairly consistent level, and if one market declines others improve and balance it, but the falling-off that is being experienced at present is almost universal. The financial difficulties in Australia have had the most serious effect on Sheffield's export business, but there are also many other markets from which it is exceptionally difficult to obtain orders just now. The home trade, through ordinary shop-keeping channels, is very flat. There is, as usual, a number of valuable contracts on hand for the equipment of hotels and steamships, and they are providing welcome work for a few firms. The scissors department is one of the bright spots in cutlery, and continues to progress in spite of the general dulness of trade. The organ of the Sheffield Chamber of Commerce reports that ten modern plants for the production of these goods on mass lines have been installed lately in Sheffield. The Cutlers' Company has purchased a portion of the Trapnell collection of old cutlery, spoons, and ladles. The specimens include pen and clasp knives, knives and forks, spoons, &c., with handles of pique, metal, amber, porcelain, pearl, enamel, and wood, of English, French, Dutch, and German manufacture of the sixteenth and seventeenth centuries. Both the silver and electro-plate trades are very quiet. The price of raw silver has marked another low record, of 1s. 5d. per ounce, but that has not benefited the trade in silver-ware to any considerable extent, although rather more has been made up into finished goods lately.

A New Bridge.

Among the schemes of road work shortly to be undertaken by the Sheffield Corporation, one of the most important is the widening of Tinsley Bridge. This is estimated to cost £120,000, of which £105,000 will be for street works and the remainder for land.

Railway Developments.

Two important schemes of railway extension to be carried out in this district are announced. One will consist of the widening of the L.M.S. line at Ambergate, near Derby. The contract for the work, which is understood to amount to about £150,000, has been placed with Shanks and McEwen, Ltd., of Glasgow, who are at present carrying out similar work for the same company near Nottingham. The other scheme is one of the L.N.E.R. for constructing an extensive new marshalling yard between Dinting and Mottram, on the main line from Sheffield to Manchester, for the purpose of relieving congestion of the heavy mineral traffic passing between Lancashire and Yorkshire centres. The sidings will cover 75 acres, and will comprise eight reception and twenty sorting sidings, with accommodation for 2000 wagons at a time. Their construction will necessitate the diversion of a portion of the main line. The work will occupy at least a year, and will provide employment for several hundreds of men.

NORTH OF ENGLAND.

(From our own Correspondent.)

Coal Trade Decline.

THE decline of the coal trade in Northumberland is reflected by the ascertainment figure for April—a figure 10 per cent. below that for March. The decrease in the amount payable to the miners above basis wages is from 39·67 per cent. in March to 28·99—the April figure—which, but for the operation of the minimum percentage of 40, would result in the men receiving 10·68 per cent. less this month than in May. Maintaining the minimum will cost the owners £24,000 out of their proceeds, this amount being added to their deficiency, which is now more than £2,400,000. The decrease does not come as a surprise to those in close touch with the coal trade, for the slackness of orders and the consequent temporary stoppage of mines in all parts of the county was expected to reveal itself in a fall in the ascertainment figure. The Durham coal trade has not been so badly hit as that of Northumberland. The ascertainment for April shows that but for the protection of the minimum percentage clause the miners would receive 49·32 per cent. on the basis wages. This is 1·86 per cent. below the return for March, and as the minimum percentage in Durham is 65, 15·86 per cent. will have to be made up from the owners' share. Durham's comparative escape from the worst rigours of the slump is due to the fact that not such a large proportion of her total sale is in the export market.

River Tees Developments.

An important step towards the completion of the River Tees improvement scheme was taken this week by the Tees Commissioners, when they accepted a Newcastle firm's tender for the work. The tender, the amount of which was not disclosed, though it was stated to be the lowest, was submitted by Purdie, Lumsden and Co., Ltd., of Newcastle. The contract is for the construction of about 8000 lineal feet of timber revetment with slag filling behind, and also an extension to a culvert across the Seal Sands on the Durham side of the river. The scheme has been promised substantial Government assistance. The contract will take five years to complete, and when it is finished an area of 267 acres of reclaimed land will be available for industrial sites.

Cleveland Iron Trade.

A slight improvement has been noticeable in the Cleveland iron trade this week. Inquiries from consumers have been more numerous, but the trouble is that they mature slowly. However, it is gratifying to note that exports to Scandinavia are on the up grade, and consumers have been forced to place orders for present needs. As a result, the increase in makers' stocks of iron seems to have been arrested, but a reduction would be very welcome to producers who find unsold stocks a financial embarrassment. Consumers apparently cling to the hope that prices will fall, and it is certainly a fact that, since the last cut in Cleveland iron prices was made, there has been a drop of 3s. in the cost of production. But this decline in the cost of production was discounted in advance, and even now there is probably no margin of profit for the pig iron producer. At all events, ironmasters keep prices firm, No. 1 Cleveland foundry iron being 70s., No. 3 G.M.B., 67s. 6d., No. 4 foundry, 66s. 6d., and No. 4 forge, 66s.

Ironworks to Close.

It is announced that Dorman, Long and Co., Middlesbrough, have decided to blow out the last of five blast-furnaces at their Newport Ironworks next week. This will mean the closing down of the ironworks. In all, sixty blast-furnaces are idle on the North-East Coast—a sad reflection of the state of the pig iron industry.

Hematite Pig Iron.

An outstanding feature of the East Coast hematite pig iron trade this week is the placing of an order for 175,000 tons with Pease and Partners, of Darlington, by a Sheffield firm. The price has not been divulged. The contract is spread over five years. The firm's only works now producing hematite iron are at Normanby, and while the new order, spread over such a long period, will not mean a very great amount of work, it will improve conditions at Normanby. Still, the order has aroused much interest, as, for a long time, transactions have been confined to business in small parcels for early delivery. It is hoped that the sale may tempt other customers to negotiate more freely. Though continental competition is severe in foreign markets, firms abroad are showing rather more disposition to draw supplies from this area and are prepared to pay more for East Coast brands than for foreign makes. Merchants' holdings of hematite are now far from heavy, but second hands are still cutting prices. Terms of sale are a matter of individual negotia-

tion. For ordinary East Coast mixed numbers ironmasters are asking 74s., but are accepting less. No. 1 quality is at a premium of 6d. per ton.

Ironmaking Materials.

A further fall in foreign iron has not attracted buyers, and it becomes more probable that some of the mines abroad will have to close. Nominally, best Rubio is 20s. per ton, c.i.f. Tees, whilst good medium blast-furnace coke is freely offered at 18s. per ton delivered at the works.

Manufactured Iron and Steel.

As regards manufactured iron and steel, a meeting is to be held this month to consider fixed quotations, but the prevailing opinion is that alterations are unlikely. Business is so dull that a stoppage this week-end will afford a welcome respite. The rail trade is the one section which presents any sign of life, and the plate and sheet mills are badly needing orders. The trouble in India is having some detrimental effect on the galvanised sheet trade.

Iron and Steel Exports and Imports.

The exports of iron and steel from the Cleveland district during May showed an increase. The total tonnage shipped was 62,833 tons, compared with 60,313 tons in April; but actually 1013 tons less steel was shipped, so that the improvement was confined to raw pig iron. Deliveries of pig iron to Scotland showed practically no improvement, but there was an increased trade with Scandinavia, Italy, and other British coastwise ports. The decline in the manufactured iron and steel shipments from 45,968 tons in April to 44,955 tons in May does not appear, on the face of it, to be serious; but the fact is that the steel export trade has been depressed all the year, and contrasted with the figures for May of last year the exports of manufactured iron and steel show a decline of 21,856 tons. Financial difficulties in Australia and the Argentine are reducing trade in two valuable markets, and whilst the demand from South Africa and India keeps fairly constant, there is no compensating improvement in any direction. The imports of iron and steel last month totalled 11,728 tons, as compared with 11,961 tons in April and 10,686 tons in May of last year.

The Coal Trade.

The Northern coal trade presents many disquieting features at the moment. If anything, the market is quieter now than it was in the closing days of May. It has reached a stage that is little short of stagnation. Producers and exporters alike agree that the position is exceptionally dull. In both Northumberland and Durham there are idle pits, and there seems to be increasing resignation to the probability of a very dull summer. Charterers have very few orders, and, with a heavy falling off in the home market, the smaller and more uneconomic pits are gradually closing down. In other years it was a common experience in the week before Whitsuntide for there to be at least some semblance of stir in the coal market, due to a desire to complete loading arrangements before the holiday. No movement of that kind has been observable on this occasion. Collieries are mostly concerned with the imminence of more lost time or, perhaps, the dismissal of more men. The Northumberland steam coal trade has shown a marked falling off, but fitters hold on to the minimum prices, and it is not easy to get second-hand holders to discount them. Large steams remain at 13s. 6d., while 12s. 9d. and 12s. are marked for Tyne primes and seconds respectively. Smalls are in quiet request at 10s. to 10s. 6d. In the main, Durham branches are dull and weak. One or two steady colliery positions prove the exception. There seems to be more tendency to shade secondary coal prices. Second gas coals and bunkers are nominally at 13s. to 13s. 3d., but odd transactions have effected reductions of a few pence. Best coking coal is unchanged at 13s. 4½d. to 13s. 6d. Sellers of best Durham and Wear special gas coal are not breaking away from 15s. 6d. and 16s. respectively, but orders are very hard to get at those figures. Coke values are weak owing to an excess of prompt supplies. Ordinary patent foundry coke is lower at 17s. to 17s. 6d., but that has not stimulated buying. Gas coke is quiet at 21s. to 21s. 6d.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

So far as the actual shipbuilding output is concerned, the total for last month was not only the highest for any month this year, but is well above the average for the period. The returns reached a total of thirty vessels of 55,644 tons aggregate. For this year to date ninety-eight vessels of 202,843 tons aggregate have been launched from Clyde yards, compared with eighty-eight vessels of 236,825 tons aggregate in the same period last year. Of the vessels launched, seven were of 4000 tons and over, the largest being the motor tanker "Laurel," 9700 tons, built for Swedish owners. Included in the list were a number of racing yachts and small motor launches, and two twin-screw cruising yachts, one of 30 tons and the other of 20 tons. A notable launch on the river Tay was the single-screw motor ship "Tanimbar," 8230 tons, built by the Caledon Shipbuilding and Engineering Company, Dundee, for the Nederlands Steamship Company, Amsterdam. In respect of new contracts placed during May, the outstanding item is, of course, the order for the new Cunarder. Some time must elapse before the actual work can be commenced, but coming at a time when work is scarce in the district, the announcement has been the source of considerable satisfaction in Clydebank, and may possibly be an inspiration to the whole Clyde industry. Other contracts were comparatively few in number, and concerned small craft, a passenger steamer for the Stranraer-Larne service and a coasting vessel for the Clyde Shipping Company. Other orders have been mentioned, but lack confirmation.

Steel.

Employment in the steel trade is somewhat uneven. One or two establishments have been working almost at full time of late, while others find difficulty in maintaining even a moderate degree of activity, and a good deal of short time has been reported. Mills producing plates for tube makers have been better off of late, as the tube works engaged in large pipes have had a good month. It is reported that one such establishment producing large pipes has enough work on hand to give employment for two years. Small tubes, however, are very quiet, the local trade having suffered to a considerable extent from the lack of Australian business. Black sheets of the thinner gauges have a steady demand, which helps to some extent to relieve the short demand for heavy gauges. Galvanised descriptions suffer from a continued scarcity of overseas business.

Iron.

The depression in the bar iron and steel re-rolling industry is unrelieved. Local producers of iron are considerably interested in the Canadian Budget proposal to impose a tariff on imported skelp when that commodity is manufactured in Canada. Skelp mills may therefore be built in Canada, to the disadvantage of local producers. Prices are unchanged, with bar iron at £10 5s. home and £9 15s. per ton export, and re-rolled steel bars are at £7 12s. 6d. per ton home or export.

Scrap.

The scrap market continues to weaken, and cast iron machinery is now quoted at 67s. 6d., with heavy steel at 55s. to 57s. 6d. and heavy basic about 58s. per ton.

Coal.

The Scottish coal market holds little of fresh interest. Land sales still diminish with the advance of the season, and export business shows no signs of improvement. A good deal of short time is reported from practically all districts. Apart from best Fifeshire steams, all descriptions of round coal are fairly plentiful, and easy in price. Washed nuts are scarcer, owing to restricted outputs, and prices are more or less unchanged. Of the contracts placed for steam coal during the week on behalf of the Finnish State Railways, the amount allotted to Scotland is 5000 tons of Lothians prime steam. Tenders have just been wired for the supply of 200,000 tons of steam coal and 8000 tons bunkers for delivery over the second half of this year for the purposes of the Swedish State Railways.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Coal Trade.

THERE has been no improvement in either the steam or anthracite coal trade of this district during the past week. Most of the steam coal undertakings are labouring under extreme difficulty in keeping their pits working with any semblance of regularity. It is true that the returns of the Great Western Railway Company of shipments last week amounted to 548,800 tons, as compared with 510,600 tons, thus showing a slight advance, but a much higher figure is needed to create activity. The number of idle tipping appliances was unusually disappointing as the week ended up with the astounding total of fifty-five. As a matter of fact, more tips were idle than there were ships loading. The position this week is not much better, as on Monday, notwithstanding arrivals of steamers, there were still thirty-six tips not working and only two vessels were waiting to berth, these being at Swansea. The fresh inquiry for coals is limited in the extreme, and though there is still a great amount of tonnage laid up orders are not forthcoming to employ the vessels that are operating. This is shown by the fact that the outward freight market instead of improving has displayed more irregularity of late. There was a hope that the approach of the holidays would have stimulated a little fresh business, but it has not materialised, and it is very evident that quietude is likely to continue during the new few weeks, as chartering operations have not been brisk enough to infuse any real life into the conditions. So far as can be ascertained, outside of an occasional inquiry for a single cargo, the only item of interest on the steam coal section is the inquiry from a leading Italian shipping company for 28,000 tons of best large steam coal for delivery during the second half of the year.

Coalfield and Docks Holidays.

The coal trimmers and tippers at South Wales docks have arranged with the employing interests for no work to be done on Monday and Tuesday next. On Wednesday there will be two short shifts, viz., 8 a.m. to 12 noon and from 12 noon to 4 p.m. On Thursday work will be resumed as usual. In the coalfield it has been arranged for no work to take place on Monday, Tuesday, and Wednesday.

Coalfield Audit.

The report of the joint accountants for the three months ended April last turns out better, if anything, than was expected. According to the statement of the secretary of the Coalowners' Association, the report certifies for the next three months a wage percentage under the terms of the present agreement of 15·05 per cent. on the 1915 standard rates. This rate compares with 18·39 per cent. certified under the previous audit, but the actual percentage payable to the workmen will be the minimum of 28 per cent. on the 1915 standard. There was a decline in the credit balance, as the profits amounted to £314,324 representing a pit-head profit per ton of 6·71d., against 9·94d. in the three months ended January last. The decrease in the certified economic percentage and the drop of practically one-third in the rate of profit per ton compared with the previous three months were due partly to an exceptional increase per ton in costs other than those of wages, and partly to a fall of nearly half a million tons in the output. On the strength of contracts entered into at improved price levels in the fall of 1929 the proceeds per ton were 2d. higher than in the three months ended January last, but it is necessary to point out that notwithstanding this slight improvement in the selling value of the coal, there have only been two or three audits which have shown credit balances under the present agreement, and that the net trading loss since 1927 amounts to no less than £4,150,884. Statistics are then given which show that the volume of production has diminished to the extent of nearly 4 per cent., and that of the foreign export trade of South Wales ports to the much higher figure of about 8 per cent., and the reasons for this reaction in the trading position of the industry are briefly a reduced demand owing to the mildness of the winter; world trade depression, due mainly to falling and unstable price levels; and conditions of business uncertainty caused by threatened legislative interference with the conditions of employment in the industry.

Shipment Charges.

The Great Western Railway Company has given notice of its intention to apply to the Minister of Transport for an order authorising it to increase the present charges for the tipping and weighing of coal and coke. Last year the Railway Rates Tribunal, as the result of an inquiry, reduced the tonnage charge for tipping and weighing coal from 7½d. a ton to 6d. per ton, and subsequently the company, on the strength of the relief given to it under the Local Government Act of 1929, further reduced the charge to 5½d. per ton. The Railway Rates Tribunal also increased the tipping and weighing charge for coke from 7½d. to 7½d. per ton. The railway company now proposes to modify existing statutory provisions, among other things, to enable it to charge not exceeding 7½d. per ton for coal and of 7½d. per ton for coke. It is expected that the application will come before the Rates Advisory Committee next month, when the traders will undoubtedly strongly oppose it.

Tin-plate Trade Items.

At the annual meeting of the Welsh Tin-plate and Sheet Trades Joint Industrial Council at Swansea last Friday, the employers rejected the workers' claim for payment of wages for the annual holiday week on the ground that the present state of trade made it impossible for them to consider the proposal favourably. With regard to the proposal for the establishment of a superannuation scheme, it was agreed by the employers that their representatives on a joint committee which was set up in connection with this matter should again give consideration to the subject. The men's side brought forward the question of the erection of additional mills, pointing out that there was no justification for them, in view of the fact that the present plant could only be utilised to the extent of 80 per cent. capacity. The matter was referred to the sub-committee for report. As regards other news concerning the industry, while it is reported that the Pentyrch Steel and Tin-plate Works at Taffs Well, near Cardiff, which have been idle since August, 1915, are to be restarted almost immediately, and will eventually employ about 300 men, the news comes to hand that notices have been posted at the Cwmfelin (Swansea) Tin-plate Works of Messrs. Richard Thomas and Co., that the works will be closed on the 28th inst. until further intimation. This stoppage will affect about 1000 men. On Monday last only ten of the nineteen mills in the works were operating. The Whitford steel sheet works at Briton Ferry, which started their mills on Monday in last week, giving employment to 250 men, restarted their galvanising plant this week, when another 200 men were taken on.

Dowlais Strike.

MEN numbering 200 to 300 employed at the Big Mill at Guest, Keen and Nettlefolds' Dowlais (Merthyr) Iron and Steel Works were idle on Tuesday as a protest against the alleged wrongful dismissal of a roller engaged in that department. They demand his reinstatement, but the management contended that the men had committed a breach of agreement in striking, and refused to discuss a settlement until the workmen restarted work.

Docks Traffic.

The G.W.R. Company's returns of sea-borne traffic at the six docks in this district under their control for the four weeks ended May 11th last showed imports and exports to amount to 2,440,575 tons, which compared with 2,916,126 tons for the preceding month and with 3,084,053 tons for the corresponding period of last year. Taking the whole of this year to May 11th, the aggregate trade comes to 13,694,895 tons, which compares with 13,694,326 tons for the same period of last year.

Current Business.

The steam coal market keeps very quiet in all branches, and prices are, in the circumstances, unaltered and are on the minima. The work at most collieries is extremely irregular, as stocks are so heavy that there is a shortage of empty wagons. Thousands of miners have been idle for days together in the various areas. The inquiry for coke is fairly steady, but it is not at all active for patent fuel. Pitwood is not imported extensively, owing to the limited demand from the collieries. The price keeps round about 25s. 9d. to 26s.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., asks us to announce that its publicity bureau has been moved from 14, Long Millgate, Manchester, to 28, Kennedy-street, Manchester (telephone number, City 9100).

KORTING BROS. (1917), Ltd., asks us to announce that on and from May 31st last its London office was closed, and that in future the whole of its business will be transacted from its registered office, Sheepbridge-lane, Mansfield.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	19/6 to 21/-
(1) Spanish	20/6 to 22/-
N.E. COAST—	
Native	18/- to 21/-
Foreign (c.i.f.)	20/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	4 1 0	—
No. 1 Foundry	4 0 6	—
No. 3 Foundry	3 18 0	—
N.E. COAST—		
Hematite Mixed Nos.	3 14 0	3 14 0
No. 1	3 14 6	3 14 6
Cleveland—		
No. 1	3 10 0	3 10 0
Silicous Iron	3 10 0	3 10 0
No. 3 G.M.B.	3 7 6	3 7 6
No. 4 Foundry	3 6 6	3 6 6
No. 4 Forge	3 6 0	3 6 0
Mottled	3 5 6	3 5 6
White	3 5 6	3 5 6
MIDLANDS—		
(3) Staffs.—	(*Delivered to Station.*)	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 15 6	—
„ „ Foundry	3 19 6	—
(3) Northampton—		
Foundry No. 3	3 15 0	—
Forge	3 11 0	—
(1) Derbyshire—		
No. 3 Foundry	3 18 6	—
Forge	3 14 6	—
(3) Lincolnshire—		
No. 3 Foundry	3 13 6	—
No. 4 Forge	3 9 6	—
Basic	—	—
(4) N.W. COAST—		
N. Lancs and Cum.—		
Hematite Mixed Nos.	4 5 6 (*a*); 4 8 6 (*b*); 4 12 6 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 10 0	—
Common Bars	10 15 0	—
Best Bars	11 5 0	—
Double Best Bars	11 15 0	—
Treble Best Bars	12 5 0	—
LANCS.—		
Crown Bars	10 5 0	—
Second Quality Bars	8 15 0	—
Hoops	13 0 0	—
S. YORKS.—		
Crown Bars	11 0 0	—
Best Bars	11 10 0	—
Hoops	12 0 0	—
MIDLANDS—		
Crown Bars	10 0 0 to 10 7 6	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	9 0 0 to 9 7 6	—
Gas Tube Strip	11 2 6	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates (Marine)	10 10 0	10 10 0
„ „ (Land)	10 0 0	10 0 0
Ship Plates, ¾in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	9 0 0	8 15 0
Sheets (Gal. Cor. 24 B.G.)	12 15 0	12 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 10 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	8 2 6	—
Soft Billets	6 17 6	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 10 0	—
Light Rails	8 15 0 to 9 0 0	—
Billets	6 15 0 to 9 10 0	—
MANCHESTER—		
Bars (Round)	9 7 6	—
„ (Small Round)	7 17 6 to 8 0 0	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	9 17 6	—
SHEFFIELD—		
Siemens Acid Billets	9 10 0 (basis)	—
Hard Basic	9 2 6 and 9 12 6	—
Intermediate Basic	7 12 6 and 8 2 6	—
Soft Basic	6 10 0	—
Hoops	9 15 0 to 10 0 0	—
Soft Wire Rods	8 0 0	—
MIDLANDS—		
Small Rolled Bars	8 0 0 to 8 15 0	—
Billets and Sheet Bars	6 0 0 to 6 12 6	—
Galv. Sheets, f.o.b. L'pool	11 17 6	—
Sheets (30 W.G.)	16 7 6	—
Angles	8 7 6	—
Joists	8 10 0	—
Tees	9 7 6	—
Bridge and Tank Plates	8 17 6	—
Boiler Plates	9 12 6	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18/- to 18/3
Block Tin (cash)	136 17 6
„ (three months)	138 15 0
Copper (cash)	53 5 0
„ (three months)	53 10 0
Spanish Lead (cash)	17 18 9
„ „ (three months)	18 3 9
Spelter (cash)	16 8 9
„ (three months)	17 3 9
MANCHESTER—	
Copper, Best Selected Ingots	61 10 0
„ Electrolytic	61 15 0
„ Strong Sheets	92 0 0
„ Tubes (Basis Price), lb.	0 1 0½
Brass Tubes (Basis Price), lb.	0 0 11½
„ Condenser, lb.	0 1 1½
Lead, English	19 12 6
„ Foreign	18 2 6
Spelter	17 5 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/1 per lb.	
Ferro Tungsten	2/10 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 12 6	7/-
„ „ 6 p.c. to 8 p.c.	£22 10 0	7/-
„ „ 8 p.c. to 10 p.c.	£22 0 0	7/-
„ „ Specially refined		
„ „ Max. 2 p.c. carbon	£33 10 0	10/-
„ „ „ 1 p.c. carbon	£38 0 0	13/6
„ „ „ 0·70 p.c. carbon	£39 0 0	15/-
„ „ „ carbon free	11d. per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£11 15 0 for home	
„ „ „	£11 0 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£11 10 0 scale 5/- per unit	
„ „ 75 p.c.	£19 0 0 scale 7/- per unit	
„ Vanadium	12/9 per lb.	
„ Molybdenum	4/2 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£170 to £175	
Ferro Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	12/6
„ „ Ell	13/3
„ „ Splint	14/3 to 15/6
„ „ Trebles	12/- to 12/6
„ „ Doubles	11/6
„ „ Singles	10/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/3
„ „ Jewel	16/-
„ „ Trebles	12/6
FIFESHIRE—	
f.o.b. Methil or Burntisland—Steam	10/3 to 12/9
Screened Navigation	16/6
Trebles	13/- to 14/-
Doubles	11/9 to 12/-
Singles	11/-
LOTHIANS—	
(f.o.b. Leith)—Best Steam	12/-
Secondary Steam	11/6
Trebles	13/-
Doubles	11/6
Singles	10/9

ENGLAND.

(8) N.W. COAST—	
Steams	20/6 to 22/-
Household	38/- to 51/-
Coke	21/- to 21/6
NORTHUMBERLAND—	
Best Steams	13/6
Second Steams	12/-
Steam Smalls	10/- to 10/6
Unscreened	13/-
Household	25/- to 37/-
DURHAM—	
Best Gas	15/6
Second	13/3 to 13/6
Household	25/- to 37/-
Foundry Coke	26/- to 29/-
SHEFFIELD—	Inland.
Best Hand-picked Branch	25/- to 26/6 —
Derbyshire Best Bright House	20/- to 22/- —
Best House Coal	19/- to 20/- —
Screened House Coal	17/- to 19/- —
„ „ Nuts	15/- to 17/- —
Yorkshire Hards	14/- to 15/6 —
Derbyshire Hards	14/- to 15/6 —
Rough Slacks	8/6 to 9/- —
Nutty Slacks	7/- to 8/- —
Smalls	3/- to 5/- —
Blast-furnace Coke (Inland)	15/6 on rail at ovens
Furnace and Foundry Coke (Export), f.o.b. 19/6 to 20/-	

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	20/-
Second Smokeless Large	18/9 to 19/9
Best Dry Large	18/6 to 18/9
Ordinary Dry Large	17/6 to 18/-
Best Black Vein Large	18/3 to 18/6
Western Valley Large	18/- to 18/3
Best Eastern Valley Large	17/9 to 18/-
Ordinary Eastern Valley Large	17/6 to 17/9
Best Steam Smalls	13/6 to 14/-
Ordinary Smalls	12/6 to 13/-
Washed Nuts	17/- to 19/-
No. 3 Rhondda Large	20/6 to 21/-
„ „ Smalls	15/6 to 16/-
No. 2 „ Large	17/- to 17/3
„ „ Through	16/- to 16/6
„ „ Smalls	14/- to 14/3
Foundry Coke (Export)	30/- to 37/-
Furnace Coke (Export)	25/- to 27/6
Patent Fuel	22/- to 22/6
Pitwood (ex ship)	25/9 to 26/-
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	35/- to 37/6
Seconds	28/- to 32/-
Red Vein	23/6 to 27/6
Machine-made Cobbles	41/6 to 45/-
Nuts	40/- to 46/-
Beans	24/6 to 27/6
Peas	20/- to 20/6
Breaker Duff	10/- to 10/6
Rubbly Culm	11/3 to 12/3
Steam Coals:	
Large	19/6 to 20/6
Seconds	18/- to 19/6
Smalls	12/6 to 13/6
Cargo Through	15/6 to 16/-

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate: Joists (minimum), 12/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 10/- if home consumers confine purchases from associated British Steel Makers.

French Engineering Notes.

(From our Correspondent in Paris.)

Machinery Abroad.

A PHASE of competition in the machine tool trade abroad that should not be overlooked is the development of design which tends to create new types, and foreign makers are seeking to impose those types on users as representing an advance in machine tool construction. The ideas come mainly from Germany, where manufacturers are giving special attention to machines for mass production. Automatic high-duty machines have their uses, but they are not universal and however much may be done to help mass production in the way of amalgamations and rationalisation, the industrial activity, in France at least, will always depend upon the general engineering shop. Specialisation has its limits, and it is by no means certain that the high-duty automatic machine will find a very extensive application. In their determined efforts to capture the French trade, German manufacturers give special prominence to the automaticity of their machines. Many of the sensitive drilling machines are automatic. There is really no necessity for it. If an automatic return of the drill enables a man to save a little time by being able to use both hands on the work, it is only done by a complication of the machine, and there has been a lot of trouble in engineering shops with some types of foreign automatic machines that are more ingenious than reliable. Still, the idea of time and labour-saving has gained a hold on the French, who take kindly to any automatic device. As labour is not abundant, they look to every means of making the best use of what is available. Another thing to be noted is the influence German design is exerting on the French machine tool industry, which is helped by the fact that Alsatian makers necessarily continue the German tradition, which is, therefore, introduced, to a certain extent, in the French industry. That has helped German manufacturers to secure a hold on the French market, and it is also tending to the creation of definite continental types which, if allowed to evolve unchecked, will finally shut out British machine tools from the market altogether. Matters have now reached a stage when British manufacturers must make a vigorous offensive against tendencies that are continually lessening their chances of doing business on the Continent. They have a good deal in their favour, for the reliability and efficiency of British machines are recognised everywhere, and they are still purchased by users who appreciate them and are prepared to pay the higher prices that are usually asked for British goods. They must be kept to the fore, and, as machine tools nowadays do not sell themselves, their merits must be prominently displayed, and when foreign buyers see that British designs are practical and economical and the machines do not need expert maintenance, there may be some reaction against present tendencies. The chairman of a leading French company has expressed great concern at the German competition in machinery, which, he states, is backed up with American capital.

Shipping.

Until last year merchant shipping was holding its own against the falling freights and it was enabled to do so, partly, by the monopoly of the colonial traffic. Since the beginning of the present year, however, the situation has been going from bad to worse. During the first quarter, the tonnage of ships laid up in French ports increased from 97,965 to 204,682. The largest increase was in the " mixed " class of steamers and in cargo boats. Of the seventeen passenger steamers laid up, fifteen were at Marseilles. Meanwhile, the situation of the shipyards continues unsatisfactory, and the Chantiers de la Gironde at Bordeaux has been sold under liquidation, the purchaser being the Société Schneider and Cie., of Creusot. Some work will be provided by the State, which has decided to construct a fleet of six ships of from 20,000 to 25,000 tons for the transport of troops across the Mediterranean. The idea is to find safety in speed, and, steaming normally at 24 to 25 knots, the ships will be capable of attaining 28 knots. The first two ships will be put on the stocks as early as possible. They will be the property of the State, but will be hired out to one of the big shipping companies.

Water Pollution.

A disagreeable experience has befallen the Lyons water supply company, against which proceedings have been taken for damages for its alleged responsibility in the case of an outbreak of typhoid fever that caused several deaths. The water is drawn from wells in the sandy basin of the Rhone, and the epidemic was caused by the pollution of two or three wells near which passed a sewage main, and it was discovered that a leakage had developed in the main at that point. The question arose whether the bacteria found in the wells came from the sewage main or from the Rhone. Several scientists and bacteriologists were called as witnesses by both sides, but their evidence was so conflicting that judgment in the case had to be adjourned.

Refuse Disposal.

The suppression of the Paris fortifications and the extension of the suburbs have had the effect of co-ordinating some of the municipal services with those of the Department of the Seine, particularly public transport and water supply, and the Prefect of the Seine has decided that household and other refuse is to be incinerated in the same way as in Paris. This has aroused a good deal of opposition from suburban municipalities, which not only decline to contribute to the cost of incinerating plants, but affirm that this method of refuse disposal is detrimental to public health. Resolutions have been passed to the effect that the operation of incineration plants should not be tolerated within a radius of 25 miles of Paris. Opponents to this system of refuse destruction also affirm that incineration is not economically satisfactory and that, in summer, it is impossible to burn a considerable proportion of vegetable matter. However that may be, the local opposition to incineration plants is directing attention to other methods of treating refuse in the hope that some system will be found that will overcome the objections of the suburban municipalities.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

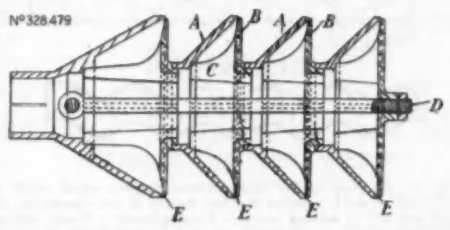
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

328,479. May 27th, 1929.—EXHAUST SILENCERS, R. Allen, Chiltern Rise, Woodcote, Oxon.

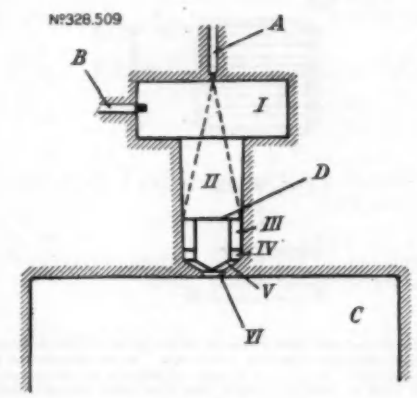
This silencer is composed of a series of conical chambers A A, each of which is almost closed by a baffle B B. The baffles have



wings C which position them in the cones and the whole assembly is held together by the bolt D. The outlet for the exhaust gases is by way of the annular orifices E E E.—*May 1st*, 1930.

328,509. July 17th, 1929.—IGNITION CHAMBER FOR HIGH-SPEED DIESEL ENGINES, Daimler-Benz Actiengesellschaft, of Stuttgart Untertürkheim, Germany.

This invention relates to recent developments in connection with small high-speed Diesel oil engines of the ante-combustion or ignition chamber type, such as are used for the propulsion of aircraft and motor vehicles. The object of the invention is to overcome slow running difficulties and to impart increased flexibility by giving to the ignition chamber certain dimensions for its individual parts, which bear a strict relation to the compression space of the engine. A definite relation is also fixed between the diameter of the cylinder wall enclosing the atomising device and the distance of the atomising head from the fuel jet. In the drawing reproduced herewith A is the fuel nozzle directing the fuel spray into the ignition chamber in communication with the main cylinder C. The ignition chamber is divided into six separate spaces or sub-chambers, which are marked by the Roman numerals I. to VI. The

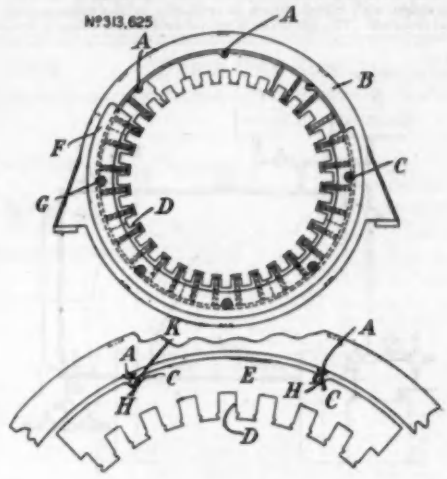


device for igniting the fuel when starting the engine is fixed in the side of chamber I. at B. Spaces I. and II. are cylindrical and either of them may be of tapered form, as shown in space II. Chamber III. is furnished with a series of ducts or passages opening at their lower ends into chamber IV. Space IV. communicates in turn with the conical-shaped chamber V., which is connected by the shallow cylindrical space VI. with the engine cylinder. The total volume of the spaces I. to VI. bear a ratio of 1 : 3·5 to 1 : 4·5 to the compression space plus the ignition chamber space. As shown in the drawing, the ratio of the total volumetric capacity of the spaces II. to VI. to the space I. is about 3 : 11, and the relative individual volumetric capacities are approximately as follows:—Space VI. being assumed as 1 volume; space V., 4 to 5 volumes; space IV., 6 to 7 volumes; space III., 10 to 11 volumes; space II., 100 to 105 volumes; and space I., 430 to 450 volumes. The ratio of the diameter of the cylindrical wall which encloses the atomiser head and the distance of the head from the fuel jet is 1 : 2·5 to 1 : 3.—*May 1st*, 1930.

DYNAMOS AND MOTORS.

313,625. June 15th, 1929.—DYNAMO-ELECTRIC MACHINES, *Associated Electrical Industries, Ltd., of Bush House, Aldwych, Westminster.*

Hitherto, stator core punchings for assembling upon stator frames have had either dove-tail projections or recesses disposed around their outer peripheries. Stator frames which are provided with punchings of such type are costly because of the fact that extra machining is necessary. In the development of fabricated stator frames, special effort has been made to provide frames which will be as strong as the cast frames previously utilised, but with less material, as well as to provide frames which may be assembled more quickly. In accordance with this invention, the spacing members A are supported at the inner periphery of the annular discs or plates of the frame B, and have fixed thereto, as by welding, cylindrical rods or bars C for supporting the laminated core D. The core comprises segmental core punchings E, which engage along their outer peripheral portions with the bars C, and which are held in face-to-face relationship by the end rings F, which receive the threaded ends of the bars C and are locked in position by the nuts G. Each core punching has two supporting recesses, which are so shaped that the punchings may be readily assembled. A portion of the material is cut away from one side wall of each recess H to provide a curved edge opposite to a sharp clinching edge K. The bolt or rod C is received through the mouth of the recess. The two recesses H in each punching are oppositely disposed, as shown in the upper illustration, in order that the clinching edges shall engage the inner sides of the rods C and the curved edges shall be at the outer sides of the rods. In the

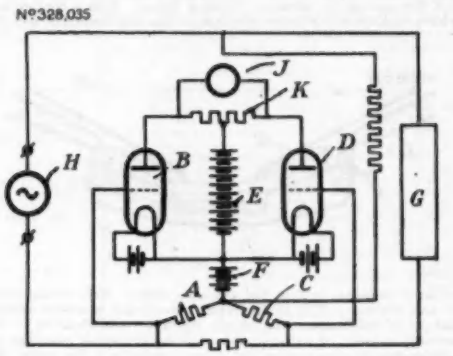


assembly operation each punching is bowed sufficiently to permit the rods C to pass through the mouths into the recesses H, and is then allowed to resume its normal shape, which it will do because of its resiliency. When the punching is in its normal position the clinching portions will hold it securely in that position.—*May 8th*, 1930.

MEASURING AND TESTING INSTRUMENTS.

328,035. January 12th, 1929.—MEANS OF MEASURING ELECTRIC POWER, Stanley Gordon Sinclair Dicker, of 20 to 23, Holborn, London, E.C. 1.

The invention relates to means for measuring electric power and more particularly to those which may be used for the measurement of power at high frequencies. The voltage across the resistance A is applied to the grid of a discharge tube B, while the voltage at the terminals of the resistance C acts on the grid of a tube D. With the aid of a high-tension battery E the grid voltage-anode current characteristic curve of the two tubes is adjusted in such manner that no positive grid voltages can occur while a grid biassing battery F supplies the voltage required for

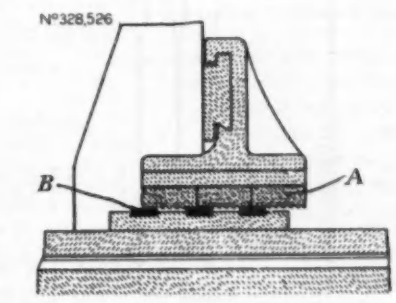


causing the tubes to operate on the curved part of the curve. In this case the anode current is a square function of the grid voltage fluctuations, and the difference of the anode currents of the discharge tubes consequently constitutes a standard for measuring power. The energy taken by the consuming device G from the alternating-current source H will consequently be determined by the deflection of the voltmeter J, which measures the voltage across the resistance K, of which equal parts are included in the two anode circuits. The above described method is very sensitive; if, however, the power to be measured is too small to obtain a sufficient deflection of the voltmeter, one or more amplification stages may be provided between the two discharge tubes B and D and the voltmeter J.—*April 14th*, 1930.

MACHINE TOOLS AND SHOP APPLIANCES.

328,526. August 27th, 1929.—CUTTING FILES, P. Unger, 37, Pastoratstrasse, Remscheid, Germany.

The inventor proposes to cut the teeth of files by a planing process, because, he says, of the great expense of the milling

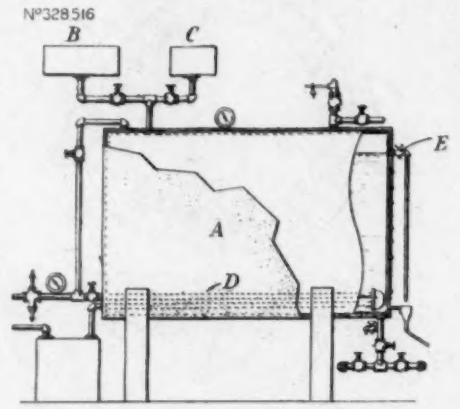


cutters otherwise employed. The planing cutters A are mounted in the tool holder of the machine and are made in sections with intervening gaps to allow for the escape of the shavings. The teeth of the cutters gradually increase in depth from front to back. The file blanks are shown at B.—*May 1st*, 1930.

GAS PRODUCERS.

328,516. July 29th, 1929.—A Process for the Recovery of Gas Tars from their Emulsions with Water, R. R. Ripley, 4439, 70th-street Southeast, Portland, Oregon; and S. C. Schwartz, 1229, East Glisan-street, Portland.

This invention is concerned with the separation of tar from its emulsion with water, which is produced in the manufacture of gas from oil. The emulsion is introduced into a vessel A from B

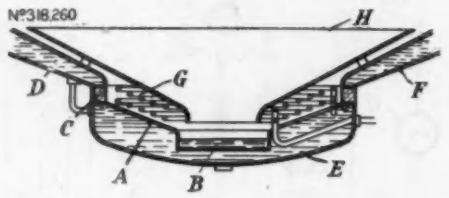


and is mixed with a solution of caustic soda from C. The mixture is then heated by means of the steam coils D until it boils. The outlet from the vessel A is then closed and the temperature and pressure raised to 320 deg. Fah. and 75 lb. respectively. The mixture is then allowed to cool slowly for some twenty-four hours, or so, and the tar is drawn off at the bottom. Test cocks are provided at E for determining the progress of the settling.—*May 1st*, 1930.

MISCELLANEOUS.

318,260. August 30th, 1929.—Mercury Vapour Rectifiers, Aktiengesellschaft Brown, Boveri & Cie., of Baden, Switzerland.

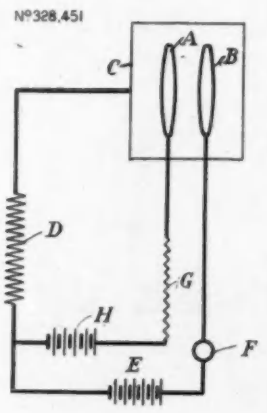
This invention relates to a mercury vapour rectifier comprising a cooled cathode vessel fixed to the bottom plate of the rectifier casing so as to be insulated therefrom and a condensation arrangement for the mercury vapour, characterised by the feature that the condensation arrangement is mounted between the rim of the depression in the cathode vessel for containing the cathode mercury and the cathode insulator. The cathode vessel A with the depression B for the cathode mercury is connected by the cathode insulator C to the bottom plate D of the rectifier casing. The cathode vessel and the bottom plate both have double walls E F for cooling by means of flowing water. G is a cooling coil which is disposed between the rim of the depression B and the



cathode insulator within the cathode vessel. The arrangement of the cooling coil G immediately above the mercury surface has, as is well known, the object, by rapid condensation of the mercury vapour, of reducing the quantity of vapour reaching the anodes and in consequence the vapour pressure in the vessel and the voltage drop in the working arc. The arrangement of the cooling coil in accordance with the invention has, however, the further advantage that the condensation takes place at the most suitable place and that the cathode insulator and its sealing places are protected from excessive heating by the arc and the mercury vapour and consequently from rapid destruction. When an arc guiding screen H is provided it may extend only so far into the cathode vessel that a sufficiently great passage area remains for the mercury vapour which flows with great velocity.—*May 1st*, 1930.

328,451. May 4th, 1929.—Photo-electric Cells, *George Beloe Ellis, of Mewburn, Ellis and Co.*, 70–72, *Chancery-lane, London, W.C. 2.*

This specification describes an improved photo-electric cell intended to give a perfectly stable photo-electric current, the intensity of which is said to be four or five times greater than



that supplied by an ordinary cell under the same conditions. In the cell, which is filled with one of the rare gases or a mixture of them, there is an annular electrode A placed between the anode B, also annular in shape, and the cathode C, which is composed of a layer of metal sensitive to light, such as lithium, deposited upon a suitable support. The cathode and the anode are connected outside the cell through a high resistance D of 500,000 ohms, for example, and a battery of primary or secondary cells E, for example, of 180 volts, the positive terminal of which is connected to the anode through a sensitive galvanometer F. The auxiliary electrode is in series with a very high resistance G, for example, 10 megohms, and is raised to a potential of 120 volts by means of a battery H having its negative terminal connected to the negative terminal of the battery in the anode circuit.—*May 1st*, 1930.

328,375. March 4th, 1929.—Making Hollow Metal Articles, T. E. Murray, 1250, Atlantic-avenue, Brooklyn, New York.

This invention covers the manufacture of such hollow metal articles as the staggered headers of water-tube boilers. The inventor makes each header of two halves, which are welded together longitudinally. The halves are made from pressings, as shown in Fig. 1, which are then bent to the sinuous form,

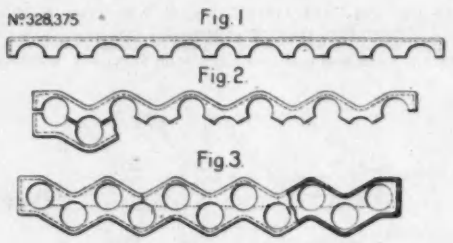
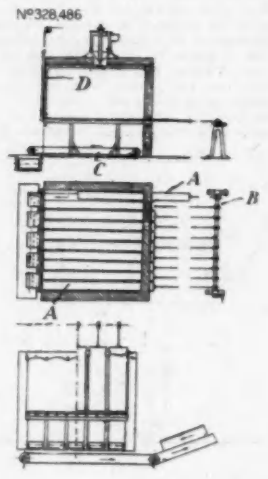


Fig. 2. In view of the large electric current which would be required to weld together the two halves in one operation, one half is made in several sections longitudinally. These sections are welded successively to the continuous half by the resistance method, and are then joined together by arc welding. The inventor says that he prefers to have the straight form of longitudinal joint shown in Fig. 3. The invention can be applied to other articles such as axle casings.—*May 1st*, 1930.

328,486. June 4th, 1929.—A Device for Mechanically Emptying Superphosphate Chambers, J. Zathey, Zniesienie, Lwów, Poland; and Towarzystow, Zlakadów Chemicznych "Strem" Spólka Akcyjna, 7, Mazowiecka, Warsaw, Poland.

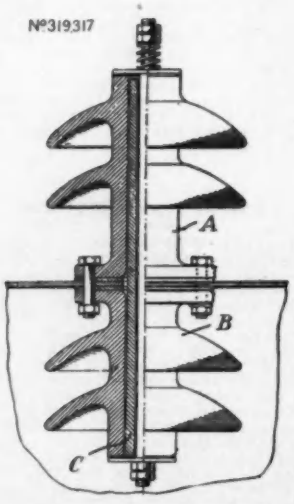
This invention is concerned with the collection and discharge of superphosphates. It is argued that the usual process of push-



ing the phosphate over the edge of the floor of the collecting chamber involves expensive machinery. As an alternative the inventors make the floor of a series of slides A A, which can be drawn back by rack and pinion gear B to allow the phosphates to drop on to the conveyor C. The disintegration of the mass in the chamber is assisted by the stainless steel wires D, which are attached to the slides.—*May 1st*, 1930.

319,317. July 15th, 1929.—Electric Insulators, Steatit-Magnesia Aktiengesellschaft, of Breite Strasse 18, Berlin-Pankow, Germany.

This invention relates to electric insulators and, in particular, it is concerned with that type of electric insulator which is built



up from a number of parts such as A and B, and is designed to lead high tension current into some container, such as the casing of gas purification apparatus, so that the insulator is liable to be subjected on one side to high temperatures. The object of the invention is completely to insulate the container wall from the member of the insulator, which carries the high tension and which is usually in the form of a bolt or the like. Effective electric insulation of the member which carries the high tension is ensured by means of an insulating tube C, surrounding the member and held in position by means of removable abutments pressed against the ends of the insulator parts by means of devices such as screw-threaded nuts, which are carried by the member which takes the high tension. Preferably, the insulating tube is made freely movable within the parts of the insulator, and the abutments are in the form of metal discs pressed on to the ends of the parts of the insulator. In practice it is found convenient to arrange insulating packings, such as asbestos discs, between the abutments and the ends of the insulator parts, and heat insulating packings, which may also, for example, be asbestos discs, may be inserted between the insulator parts and the leading-in point.—*May 8th*, 1930.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY TO MONDAY, JUNE 9TH.

Institution of Gas Engineers.—Conference at Leeds. For programme see issue May 9th, 1930, page 528.

SATURDAY, JUNE 7TH.

Institution of Engineers-in-Charge.—Visit to the Kempton Park works of the Metropolitan Water Board. 3 p.m.

THURSDAY, JUNE 12TH.

Institution of Municipal and County Engineers.—Northern Irish District meeting, Manager's office, Corporation Gasworks, Ormeau-road, Belfast. 3 p.m.

FRIDAY, JUNE 13TH.

Royal Institution of Great Britain.—21, Albemarle-street, W. 1. Discourse on "Unemployment," by Professor Henry Clay. 9 p.m.

SATURDAY, JUNE 14TH.

Institution of Municipal and County Engineers.—South-Eastern District meeting at Richmond and Barnes. The Council Chamber, Town Hall, Richmond. 12 noon.

WEDNESDAY, JUNE 18TH.

Institution of Municipal and County Engineers.—South-Western District meeting at Torquay, the Town Hall. 2 p.m.

FRIDAY, JUNE 20TH.

Institution of Municipal and County Engineers.—South Midland District meeting to be held at Harpenden. Assemble at Public Hall, The Common, Harpenden, 11 a.m.; 11.20 a.m., inspect the road widening scheme, Piggottshill-lane; 11.40 a.m., visit the sewage disposal works; 12.30 p.m., luncheon at the Trust House, Cock Inn, High-street; 2 p.m., inspect the new 350,000-gallon reinforced concrete water tower and tank of the Harpenden Water Company; 2.30 p.m., inspect the new pumping station of the Harpenden Water Company near The Hyde; 3.30 p.m., return to Harpenden to inspect the new concrete road in course of construction on the housing site; if time permits, the new cemetery adjoining may be inspected; 4.30 p.m., tea at the Public Hall; a paper descriptive of the road works and sewage disposal works will be given by the Engineer to the Council, Mr. W. H. Johnson. Discussion after tea.

SATURDAY, JUNE 21ST.

Institution of Engineers-in-Charge.—Visit to the National Physical Laboratory, Bushey House, Teddington. 3 p.m.

SATURDAY TO SATURDAY, JUNE 21ST TO 28TH.

Royal Sanitary Institute.—Congress and Health Exhibition at Margate.

TUESDAY, JUNE 24TH.

Advertising Convention, 1930.—Industrial Press Session Luncheon, Royal Victoria Hotel, Hastings, after which a number of speakers will give their views on various matters connected with the trade and technical Press:—Professor Henry Clay, "British Industry's Message to the World;" Mr. Holbrook Jackson, "The Voice of Industry—the Trade Press;" Mr. C. Pinkham, "The Service Expected from a Trade Journal;" Mr. P. Best, "The Trade Journal as a Link between Manufacturer and Distributor."

WEDNESDAY, JUNE 25TH.

Institution of Civil Engineers: Yorkshire Association.—Visit to Barnsley Waterworks. Meet at Scout Dike Reservoir (on the Penistone-Huddersfield Road, about 1½ miles from Penistone). 11.30 a.m.

Staffordshire Iron and Steel Institute.—Visit to Port of Bristol.

WEDNESDAY TO WEDNESDAY, SEPTEMBER 3RD TO 10TH.

British Association for the Advancement of Science.—Bristol meeting. The presidential address, by Professor F. O. Bower, will deal with "Size and Form in Plants." Evening discourses will be given by Professor E. V. Appleton, F.R.S., on "Wireless Echoes," and by Dr. R. E. Slade on "The Nitrogen Industry and our Food Supply." Evening receptions and excursions to points of scientific interest, works, &c., in the locality will be arranged.

THURSDAY TO SUNDAY, SEPTEMBER 4TH TO 7TH.

International Congress of Consulting Engineers.—Fifth Congress at Vienna.

New Coke Ovens near Sheffield.—Through a typographical error some of the titles over the illustrations in our description of the new coke ovens at Smithywood are misspelt. The name of the owners is, as is given in the text, Thorncliffe Coal Distillation, Ltd., not Distribution, as given over the pictures.

Exhibition of Inventions.—The sixth International Exhibition of Inventions will be held in the Central Hall, Westminster, from October 1st to 11th next. As in previous years, the Exhibition will comprise a Trade Section, in which the goods shown will be offered for sale, and a New Inventions Section, in which the inventions shown will not have reached the marketing stage.